USBORNE GUIDE TO COMPUTER and VIDEO GAMES

How they work and how to win

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USBORNE GUIDE TO COMPUTER and VIDEO GAMES

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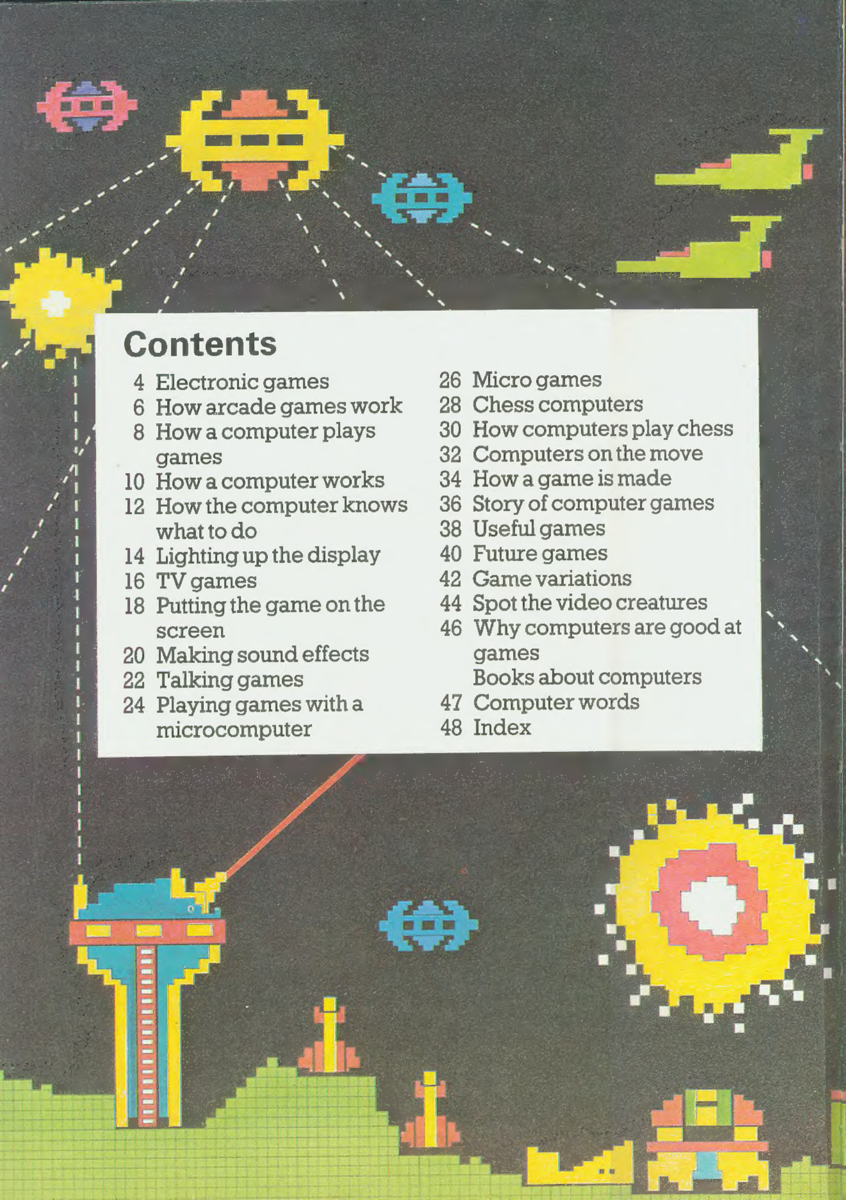
This book was designed by Round Designs and Roger Priddy and illustrated by Graham Smith, Graham Round, Ian Stephen and Tony Morris.
Thanks to Simon Lowe for arcade games playing tips.
The names of the games in this book are registered trade marks. The book has been produced independently of the games manufacturers and the winning strategies for the games have been devised by our own experts.



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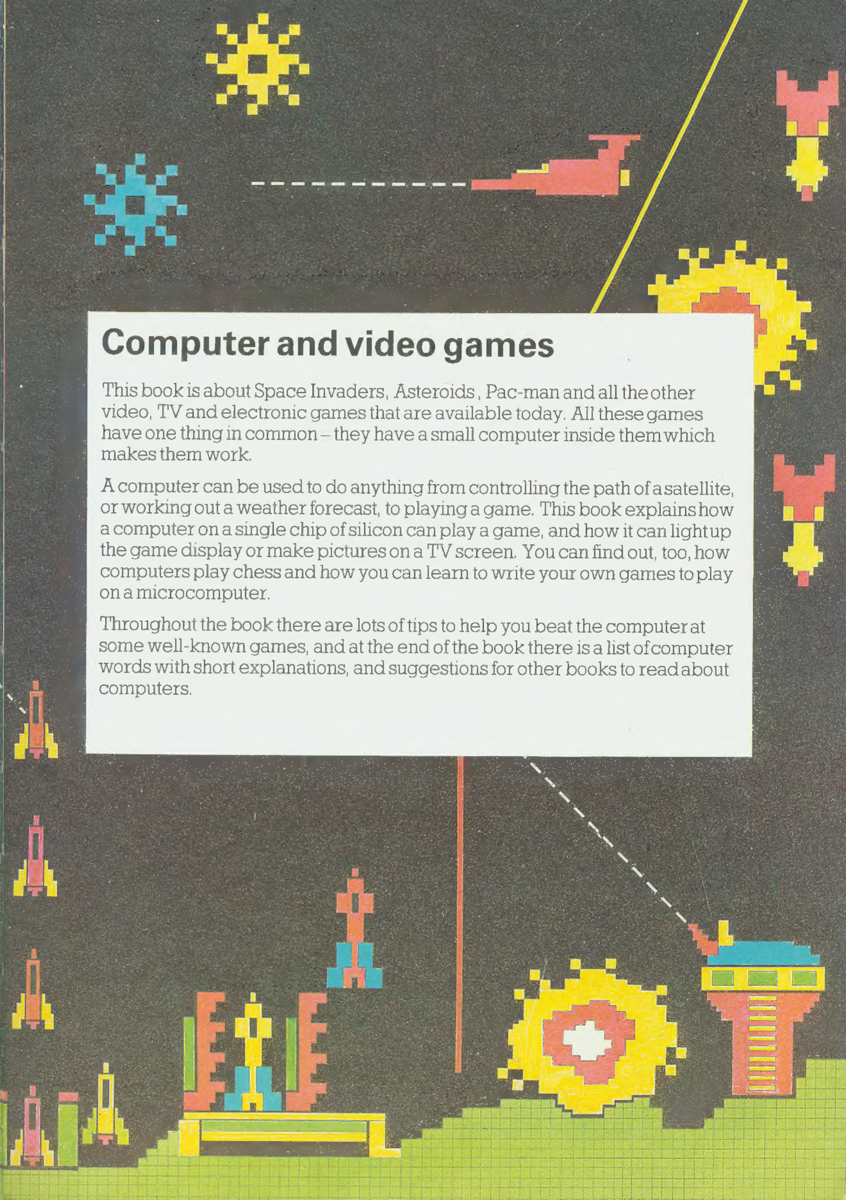


Computer and video games

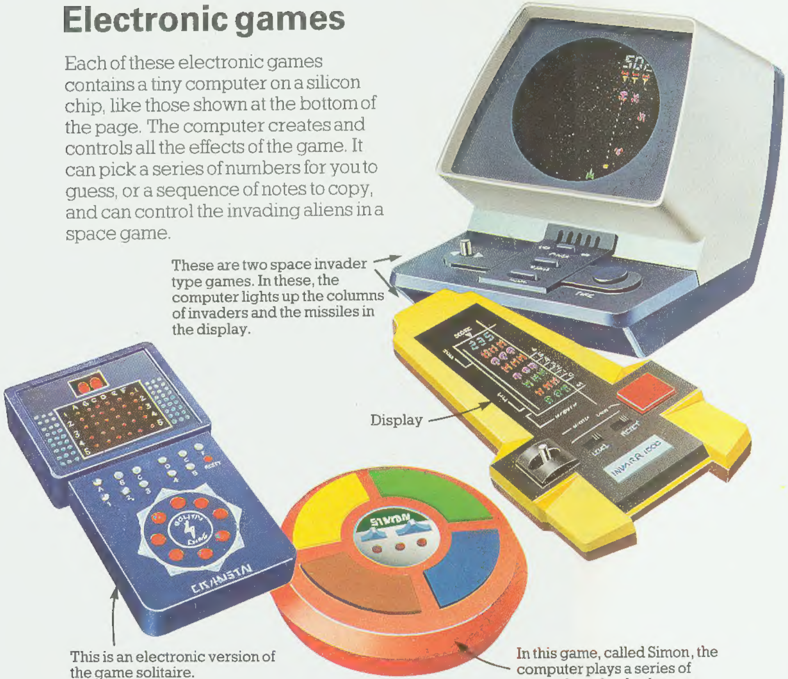
This book is about Space Invaders, Asteroids, Pac-man and all the other video, TV and electronic games that are available today. All these games have one thing in common – they have a small computer inside them which makes them work.

A computer can be used to do anything from controlling the path of a satellite, or working out a weather forecast, to playing a game. This book explains how a computer on a single chip of silicon can play a game, and how it can light up the game display or make pictures on a TV screen. You can find out, too, how computers play chess and how you can learn to write your own games to play on a microcomputer.

Throughout the book there are lots of tips to help you beat the computer at some well-known games, and at the end of the book there is a list of computer words with short explanations, and suggestions for other books to read about computers.

Electronic games

Each of these electronic games contains a tiny computer on a silicon chip, like those shown at the bottom of the page. The computer creates and controls all the effects of the game. It can pick a series of numbers for you to guess, or a sequence of notes to copy, and can control the invading aliens in a space game.



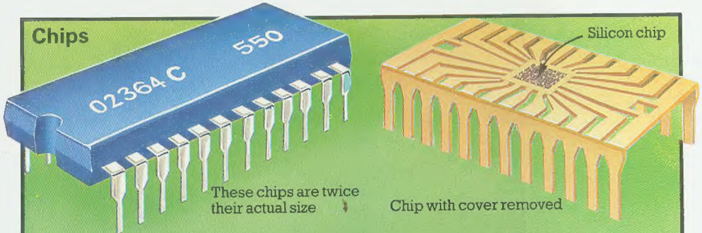
These are two space invader type games. In these, the computer lights up the columns of invaders and the missiles in the display.

Display

This is an electronic version of the game solitaire.

In this game, called Simon, the computer plays a series of notes, then checks that you copy them correctly.

Chips



Silicon chip

These chips are twice their actual size

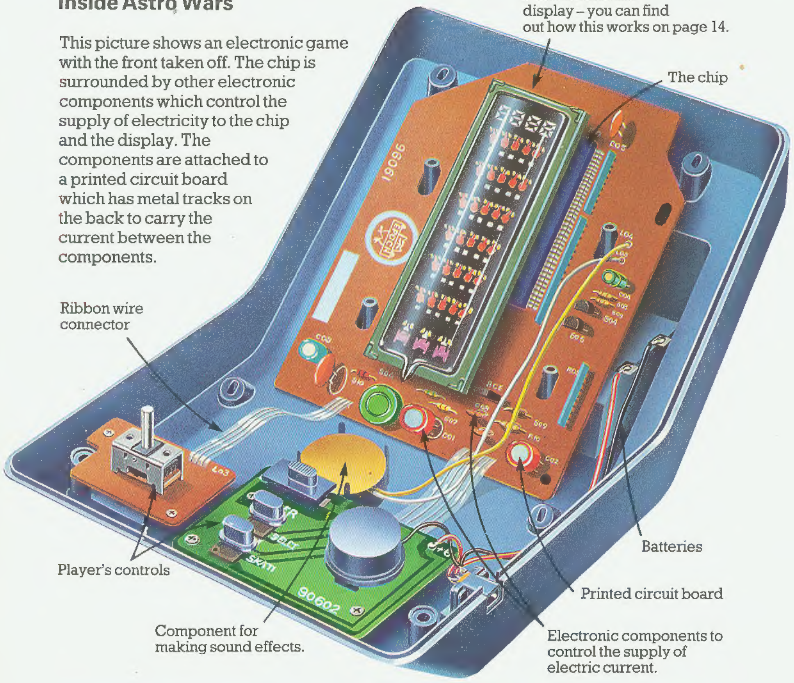
Chip with cover removed

A chip is a powerhouse of minute electrical circuits pulsing with tiny currents of electricity. The electrical circuits are embedded in the small slice of silicon after which the chip is named.

The picture above shows two chips, one with its cover removed to show the chip of silicon. All the work of the computer is done by the pulses of electricity flowing through the chip.

Inside Astro Wars

This picture shows an electronic game with the front taken off. The chip is surrounded by other electronic components which control the supply of electricity to the chip and the display. The components are attached to a printed circuit board which has metal tracks on the back to carry the current between the components.



Fluorescent tube display – you can find out how this works on page 14.

The chip

Ribbon wire connector

Player's controls

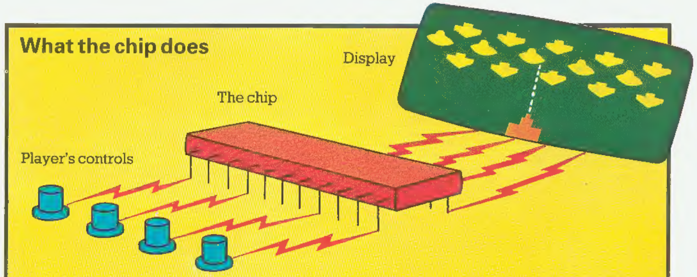
Component for making sound effects.

Batteries

Printed circuit board

Electronic components to control the supply of electric current.

What the chip does



Display

The chip

Player's controls

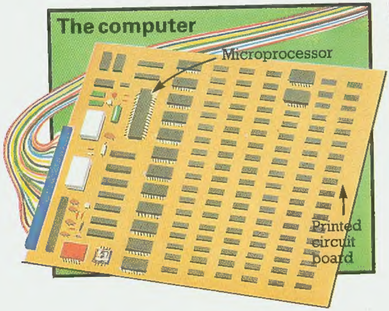
The chip is the brain and control centre of the game. It contains all the information about the game and controls the action in the display, and the sound effects.

It also receives messages from the player's controls, processes them and sends them on to the display. You will find out how the chip does all these things as you read through this book.

How arcade games work

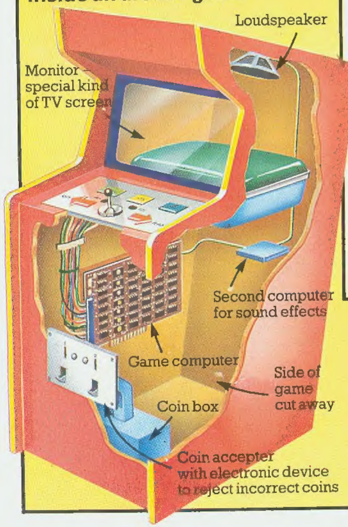
Arcade games have much larger, more powerful computers than hand-held electronic games, so the games are more exciting and complex.

The computer

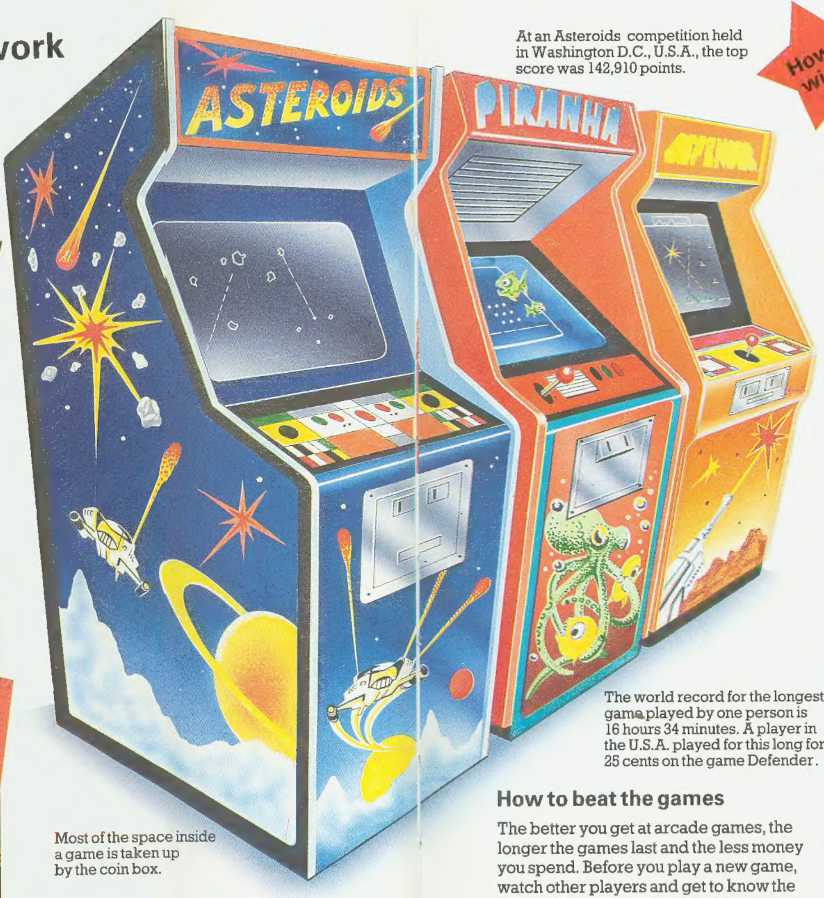


An arcade game computer has over a hundred chips connected together on a printed circuit board. Each chip has its own job to do and they are controlled by a master chip called the microprocessor.

Inside an arcade game


Loudspeaker
Monitor – special kind of TV screen
Second computer for sound effects
Game computer
Side of game cut away
Coin box
Coin accepter with electronic device to reject incorrect coins

An arcade game usually has two computers, one to control the game and another for the sound effects. The main game computer contains all the information for the game and processes the messages from the player's controls. It also receives electronic messages from the coin accepter and only starts the game when the correct coins are received.



Most of the space inside a game is taken up by the coin box.

At an Asteroids competition held in Washington D.C., U.S.A., the top score was 142,910 points.

The world record for the longest game played by one person is 16 hours 34 minutes. A player in the U.S.A. played for this long for 25 cents on the game Defender.

How to beat the games

The better you get at arcade games, the longer the games last and the less money you spend. Before you play a new game, watch other players and get to know the game. Try and develop a plan, or strategy, for beating the computer. There are lots of tips from experts to help you in this book.

The game created by the computer is always the same and once you get to know it you will probably recognize the pattern. Most games have special sequences which start at certain scores. The arcade operator can decide the score at which the sequences start, and also how many "lives" you get, so try playing the game on various machines to see if it is different.

How to win at ASTEROIDS

The aim of this game is to gain points by destroying asteroids and flying saucers by firing from your spaceship. Destroying the small flying saucers gives you the most points. A good playing strategy is to clear the screen of all but one asteroid (if you destroy them all, a complete new set appears), then wait for the small flying saucer.

At the beginning of the game it is safer to stay in the middle of the screen. If you move around you may bump into a rock. Watch out for the small asteroids. These travel faster than the larger ones, so if there are any hurtling towards your ship, shoot at them first. Aim in front of rocks, so they fly into your fire.

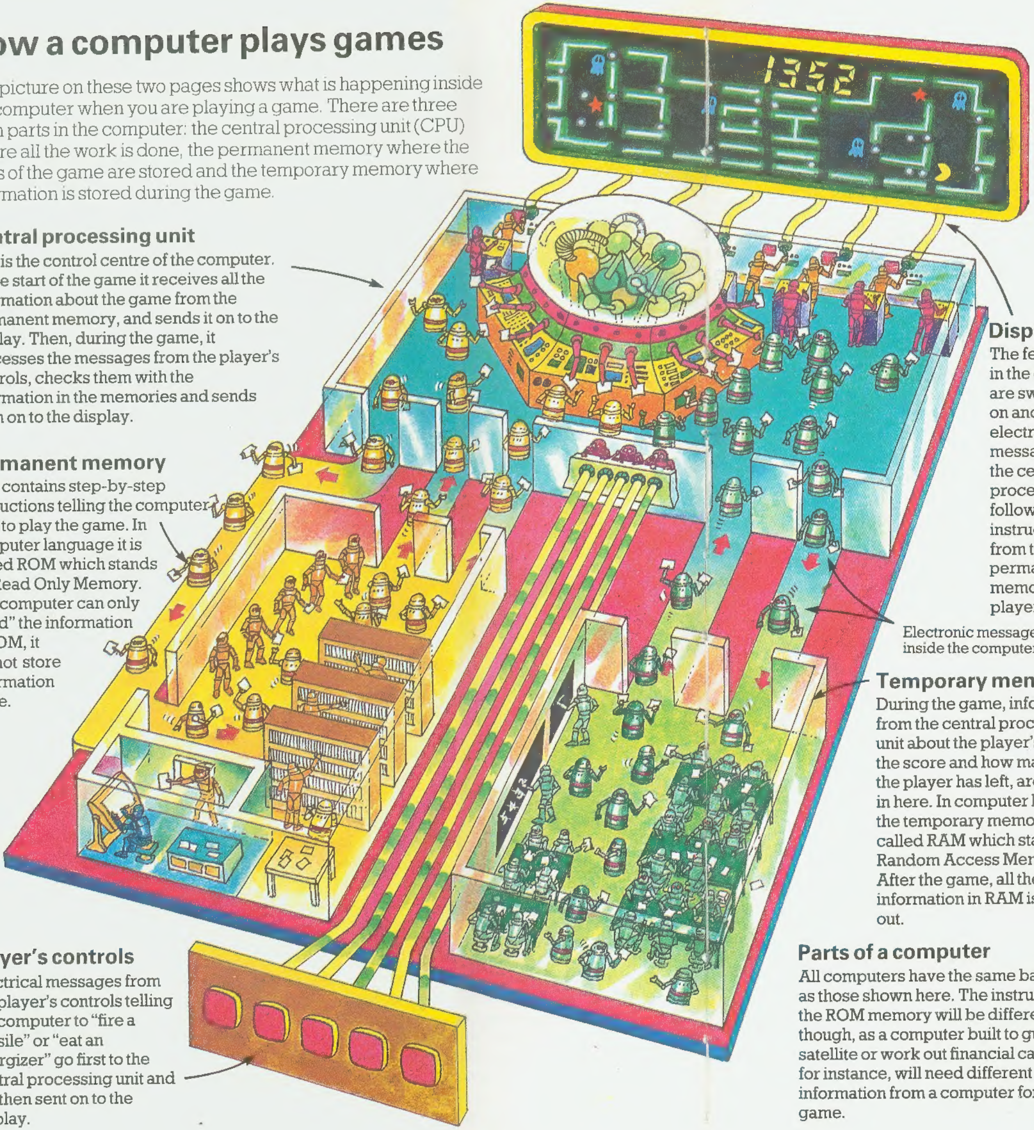
Only use hyperspace in dire emergencies, for instance, if you cannot avoid crashing into a rock. When you re-enter the screen you have approximately a one in five chance of hitting something.

The large saucer fires at random, but the small one can aim at you, so while you are waiting for it, keep using thrust. If you stay still, the saucer will aim to hit you as soon as it appears, and the higher your score, the more accurate its aim becomes.

A tip from the game manufacturer, Atari – the maximum number of objects that can appear on the screen at one time is 35 (27 rocks, 1 saucer, 2 saucer bullets, your ship and 4 of your bullets). If you have broken up lots of large rocks and are getting close to this number of objects, unusual things can happen on the screen. For instance, you can destroy a large rock with one bullet.

How a computer plays games

The picture on these two pages shows what is happening inside the computer when you are playing a game. There are three main parts in the computer: the central processing unit (CPU) where all the work is done, the permanent memory where the rules of the game are stored and the temporary memory where information is stored during the game.


1352
Electronic messages inside the computer

Central processing unit

This is the control centre of the computer. At the start of the game it receives all the information about the game from the permanent memory, and sends it on to the display. Then, during the game, it processes the messages from the player's controls, checks them with the information in the memories and sends them on to the display.

Permanent memory

This contains step-by-step instructions telling the computer how to play the game. In computer language it is called ROM which stands for Read Only Memory. The computer can only "read" the information in ROM, it cannot store information there.

Player's controls

Electrical messages from the player's controls telling the computer to "fire a missile" or "eat an energizer" go first to the central processing unit and are then sent on to the display.

Display

The features in the display are switched on and off by electrical messages from the central processing unit, following instructions from the permanent memory and the player's controls.

Temporary memory

During the game, information from the central processing unit about the player's moves, the score and how many "lives" the player has left, are stored in here. In computer language the temporary memory is called RAM which stands for Random Access Memory. After the game, all the information in RAM is wiped out.

Parts of a computer

All computers have the same basic parts as those shown here. The instructions in the ROM memory will be different, though, as a computer built to guide a satellite or work out financial calculations, for instance, will need different information from a computer for playing a game.

How to win at

MISSILE COMMAND

In this game you control three missile bases and have to defend cities from aerial attack. You gain points for destroying the attackers and for the number of missiles and cities you have left at the end of each phase of the game.

At the beginning of the game, try and destroy as many as possible of the first wave of attack missiles with an intensive barrage of fire across the centre of the screen. Then aim at any remaining missiles, shooting the lowest ones first before they reach your bases and cities.

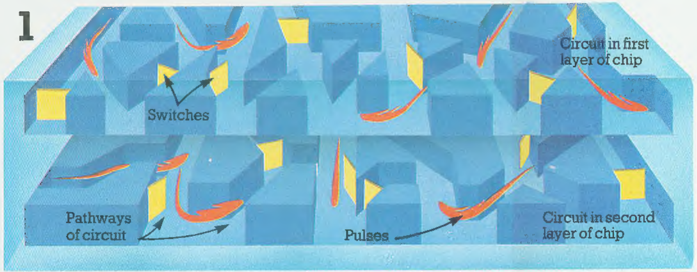
During the game, concentrate on defending your bases. If all your bases are destroyed you will have no missiles left to defend the cities. To keep the game going, though, you must have one city intact at the end of each phase of the game.

Each time you score a certain number of points (usually 10,000) you are given a bonus city. Expert players try to win a city towards the end of a phase so they do not have to defend it throughout the attack.

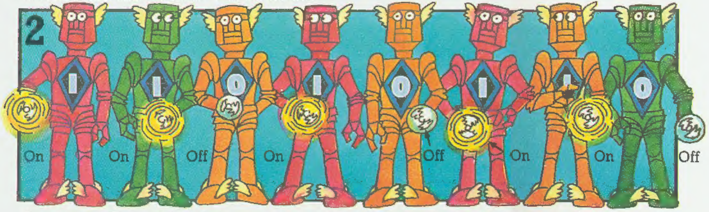
When the bombers appear, try to hit them before they can drop their bombs on you, and attack enemy missiles before they can split and become doubly dangerous. With skill and timing, you can aim at the point where the paths of two attackers will cross and destroy them both with the same fire. Use up all the missiles from the end bases first, then you need no longer defend them. Do not win more cities than you need to keep the game going. You will have extra work defending them.

How a computer works

A computer consists of intricate sets of minute electrical circuits engraved on tiny chips of silicon. The circuits are pulsing with thousands of tiny currents of electricity.

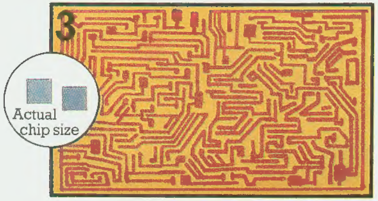

1
Circuit in first layer of chip
Switches
Pathways of circuit
Pulses
Circuit in second layer of chip

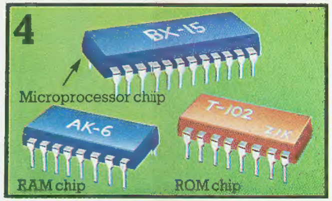
This picture shows the circuits in two of the many layers of a chip. The circuits are complicated networks of pathways and they contain microscopic switches. The switches turn the currents off and on and convert them into streams of pulses, shown here by red flashes. The pulses are the signals in a code which the computer uses to do all its work.



There are only two signals in computer code: "on" (pulse) and "off" (no-pulse). In this picture the signals are shown by the robots' torches. The signals can also be represented by numbers, using 1 for on and 0 for off.*

Each piece of information in the computer is represented by a group of eight signals, that is, ons (1s) and offs (0s). Each group is called a "byte". Each signal is called a "bit".





This picture shows one of the circuits on a chip, enlarged many times. Each part of the computer has different circuits to produce and control different patterns of pulses.

The circuits for the different parts of the computer may be in different chips, or they may all be contained in a single chip called a microprocessor. You can find out how a chip is made on pages 34-35.

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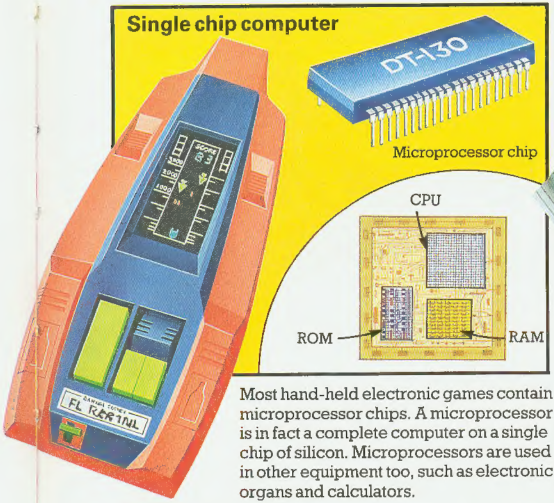
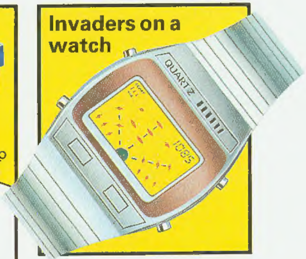
*A code based on the two digits 1 and 0 is called binary code.

Single chip computer



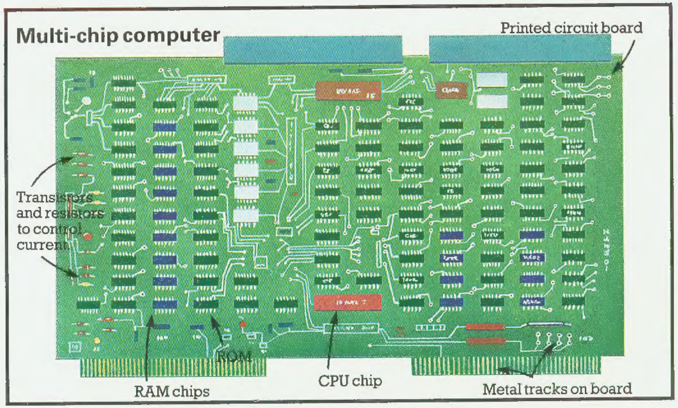
Most hand-held electronic games contain microprocessor chips. A microprocessor is in fact a complete computer on a single chip of silicon. Microprocessors are used in other equipment too, such as electronic organs and calculators.

Invaders on a watch



This watch is run by a microprocessor chip and it can play an invaders game as well as telling the time. The chip is like the one on the left and it controls all the functions of the watch, including the date, an alarm and a stopwatch as well as the time and game. Some watches contain a small calculator, too.

Multi-chip computer



More powerful computers, like the ones in arcade games, have lots of different chips. For instance, there are ROM chips and RAM chips and other chips to translate the messages coming into the computer into binary code. All the chips are connected together on a printed circuit board, with a large microprocessor chip to control them all.

A computer with lots of chips has far more processing power and memory space than a single chip computer. The size of the memory is measured by the number of bytes it can store. Most hand-held games have a memory of about 2,000 bytes (that is enough for about 2,000 pieces of information). An arcade game has about 32,000 bytes of memory.

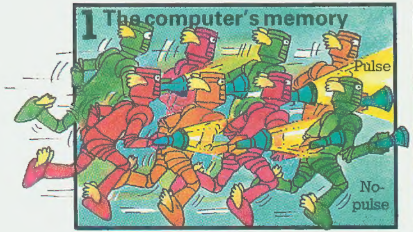
How the computer knows what to do

The instructions telling a computer what to do are called a program* and they are stored in the computer's memory. There are two ways of giving a computer its program: it can be built into the computer when it is made, or put into the computer each time you use it.

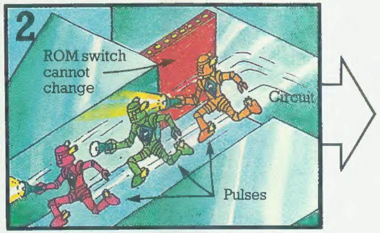
Computers with built-in programs can do only the tasks for which they are made. They are called dedicated computers. Computers which can be given different instructions each time you use them are called programmable computers.

▲Most hand-held electronic games, and arcade games, have dedicated computers. They can play only the games for which they were programmed when they were built.

▲You can play lots of different games with this hand-held game, by fitting different cartridges into the main game unit. It is not really programmable, though, as you cannot write your own programs for it. Each games cartridge contains a memory chip with the program for a game in it. The main game unit contains a microprocessor chip which processes the information from the memory chip.



This picture shows a group of pulses and no-pulses representing a piece of information in computer code. Each instruction in the computer's memory is represented by a different group of pulses and no-pulses.



In a dedicated computer the instructions are stored in ROM. This is done by setting the switches at the time of manufacture so they produce the same groups of pulses every time the current flows through them.

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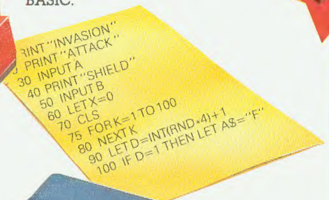
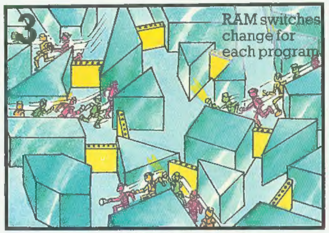
*Usually spelt like this in computer language.

This is part of a program for a microcomputer. It is written in a special computer language called BASIC.



```
RINT "INVASION"
PRINT "ATTACK"
30 INPUT A
40 PRINT "SHIELD"
50 INPUT B
60 LET X=0
70 CLS
75 FOR K=1 TO 100
80 NEXT K
90 LET D=INT(RND*4)+1
100 IF D=1 THEN LET A$="F"
```

▲A microcomputer, like this one, is a programmable computer. You can program it to play a game, or draw pictures, work out complicated calculations, or whatever you like. You plug it into a TV, then program it by typing instructions on the keyboard. You can find out more about playing games on a microcomputer on pages 24-27.


3
RAM switches change for each program

In a programmable computer the program is stored in RAM. Each time you put a different program into the computer, the positions of the switches in the RAM circuits are changed to produce different groups of pulses.

How to win at

PAC-MAN

There are lots of different versions of this game in which you guide the Pac-man round the maze, eating dots, fruits and energizers while being chased by monsters.

Pac-man experts gain scores of over 300,000. The trick is to eat as many dots and fruits as possible and save the energizers until the best moment for eating the monsters. As in other games, leave one dot or energizer on the screen until you want a new set to appear.
Try and avoid the paths with energizers until you are ready to attack the monsters. Until then, only eat an energizer in an emergency if several monsters are closing in on you.

Before you use the emergency exits at the sides of the maze, make sure the other side of the maze is clear. There may be a monster lurking there ready to eat you as you re-enter the maze.

How to win at

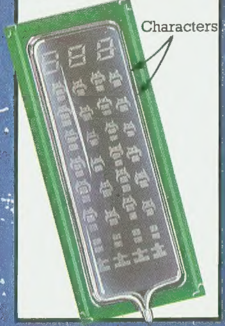
QIX

This is a difficult game in which you try to colour in the screen with your drawing head, while being attacked by the Qix, Sparx and Fuses.
Start the game well away from the Qix and keep an eye on the Fuses which chase you along unfinished lines. Do not let them touch your drawing head.
Try and draw a network of open-ended boxes to trap the Qix in. If you manage to lure it into a box, quickly seal it up with another line, then switch to fast draw and try and fill in as much of the screen as possible. If you fill in over 75% of the screen you win a new game.

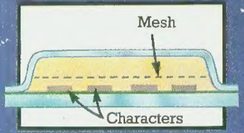
Lighting up the display

These two pages show how the computer lights up the display in a hand-held game. There are two different ways of creating the display. One way uses a fluorescent tube which works on the same principles as a neon light. The other uses liquid crystal which turns black when an electric current passes through it. It is easier to make detailed pictures with liquid crystal.

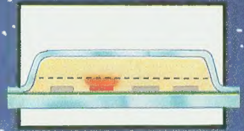
Fluorescent tube



In this system all the characters in the display are fixed to a board inside a glass tube and the tube is full of gas.



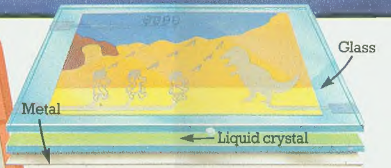
The characters are made of a material which conducts electricity and above them there is a fine metal mesh.



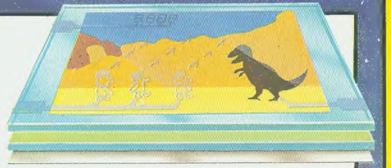
The mesh has a small charge of electricity. When a charge is sent to one of the characters, current flows between it and the mesh, lighting the gas in between.

By lighting up the characters one after another, it looks as though they are marching down the screen.

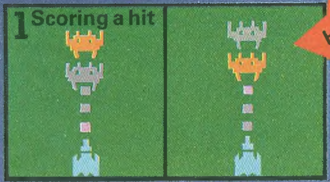
Liquid crystal display



The shapes of all the characters are etched on two pieces of glass in a way that makes them able to conduct electricity. The pieces of glass are sandwiched together with the transparent liquid crystal between them and a metal foil reflector behind them.

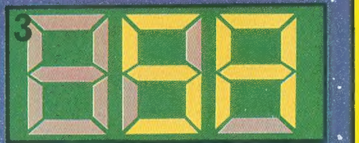


Messages from the computer send currents of electricity to the shapes in the glass. When the currents pass through the liquid crystal between the shapes, the crystal becomes turbulent. Light can no longer pass through it so the shapes appear black.



Messages from the computer light up the missiles one after the other. When the missile next to an invader lights up, the computer registers a hit.

It records the hit in its RAM memory and sends a message to the display to add a figure to the score. It may also send messages to the loudspeaker.



Each figure in the score is made of seven segments of material which conducts electricity. By switching on various combinations of segments it is possible to make all the figures from zero to nine and most letters of the alphabet.

How to win at BATTLEZONE

In this game you are in a tank and the screen shows your view of the landscape outside. You gain points by shooting enemy tanks, supertanks, missiles and saucers.

Experts gain scores of around 150,000 points at this game. To get a high score you have to destroy 20 tanks as quickly as possible. After this the supertanks, missiles and saucers appear. These are worth far more points than the ordinary tanks. (The number of tanks you have to destroy before the supertanks appear varies on different machines.)

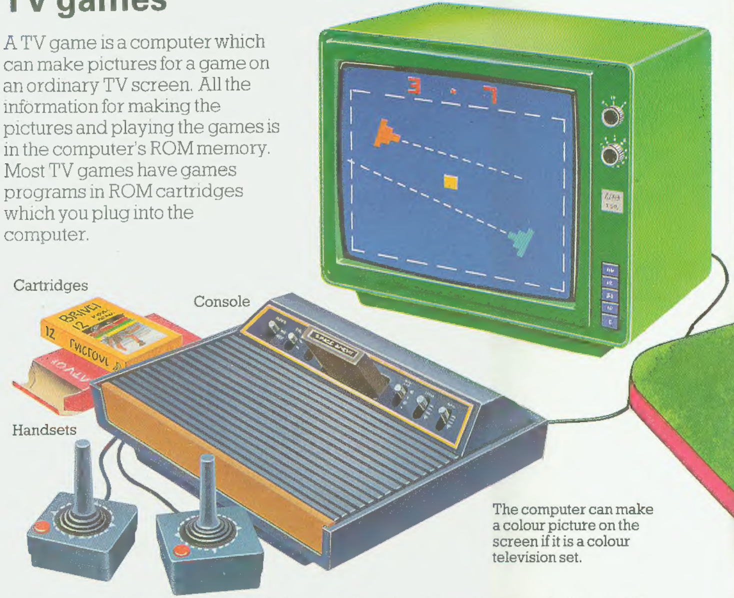
Try to approach an enemy tank from the side or the back, so it cannot shoot at you. Then, when you get close, turn to face it, line it up in your sights and fire before it turns to shoot at you. If you miss or are too slow, quickly escape by moving out of the enemy's line of fire. You can then move around the enemy and come in from another side. Use your radar screen to judge your position and manoeuvre until the dot representing the enemy is almost touching the angle which represents your field of vision.

When a supertank appears, use the same tactics to destroy it. Then wait safely behind an obstacle for a missile or flying saucer. The cubes are useful objects to hide behind as you can fire over them without exposing yourself to danger.

The missiles will fly straight at you, but they are difficult to hit, so do not shoot them until they are quite close. The saucers are much easier to hit, but do not chase them as you will be open to attack from enemy tanks.

TV games

A TV game is a computer which can make pictures for a game on an ordinary TV screen. All the information for making the pictures and playing the games is in the computer's ROM memory. Most TV games have games programs in ROM cartridges which you plug into the computer.



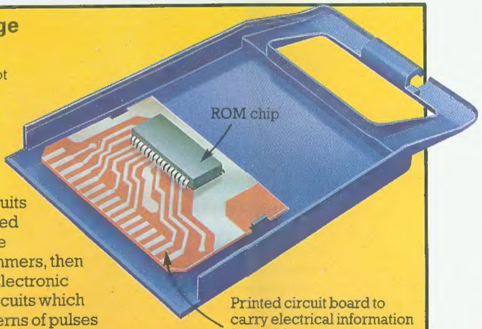
The computer can make a colour picture on the screen if it is a colour television set.

The computer for a TV game is called a console. It contains all the chips for running the game, except for the ROM chips. You plug the console into the aerial socket on the TV and when you are playing a game, the TV receives signals from the computer, instead of from a TV station. Most TV games have a switch for playing games at different skill levels. This tells the computer to play a different version of the game program, or to run it at a different speed.

Inside a games cartridge

Games cartridges have to be kept clean as dust on the printed circuit board can interfere with the flow of electrical information from the chip.

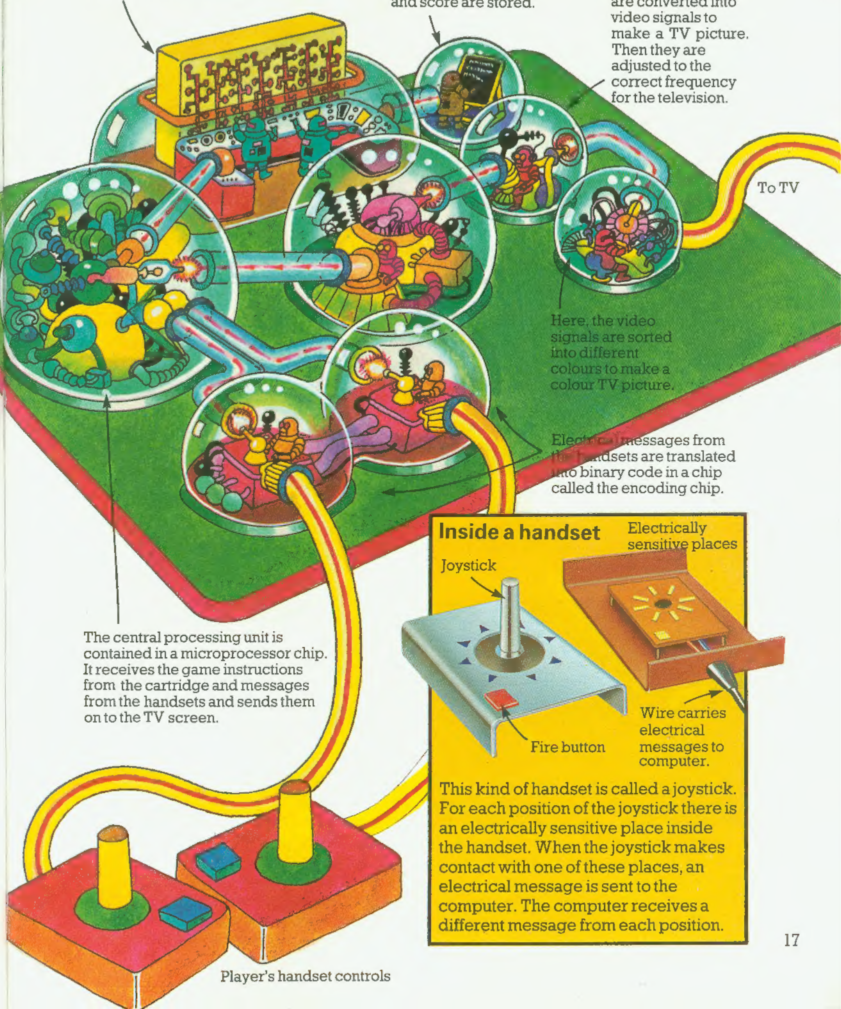
Each cartridge contains a single ROM chip and the circuits in a chip are specially designed for each game. The games are written by computer programmers, then translated into binary code. Electronic engineers then design the circuits which will produce the correct patterns of pulses in the chip.



Printed circuit board to carry electrical information from chip to computer.

How a TV game works

This picture shows how the computer in a TV game console works, and how it sends messages to the TV screen to make the pictures.



All the information about the game flows into the computer from the game cartridge.

Temporary memory (RAM) where details of the player's moves and score are stored.

Here, messages in computer code from the microprocessor are converted into video signals to make a TV picture. Then they are adjusted to the correct frequency for the television.

Here, the video signals are sorted into different colours to make a colour TV picture.

Electrical messages from the handsets are translated into binary code in a chip called the encoding chip.

The central processing unit is contained in a microprocessor chip. It receives the game instructions from the cartridge and messages from the handsets and sends them on to the TV screen.

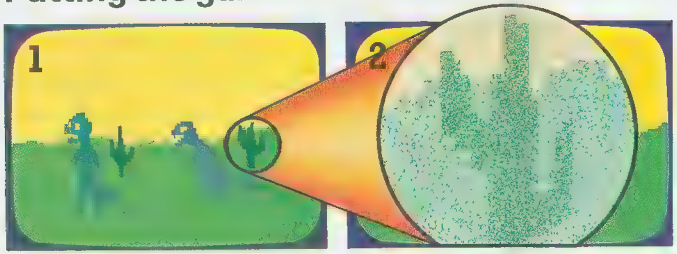
Player's handset controls

Inside a handset

Wire carries electrical messages to computer.

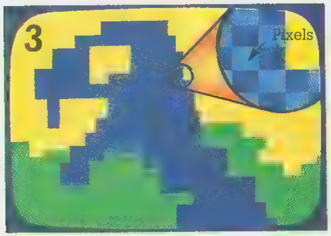
This kind of handset is called a joystick. For each position of the joystick there is an electrically sensitive place inside the handset. When the joystick makes contact with one of these places, an electrical message is sent to the computer. The computer receives a different message from each position.

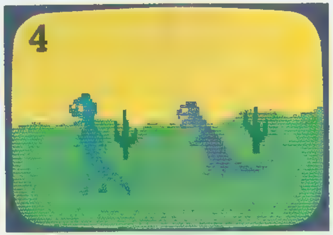
Putting the game on the screen



To put the picture for a game on a TV screen the computer has to translate all the information in its memory into video signals which the television can understand.

If you look closely at the picture on a colour TV screen you can see that it is made up of tiny coloured dots. When you play a TV game the colour of the dots is decided by instructions from the computer.

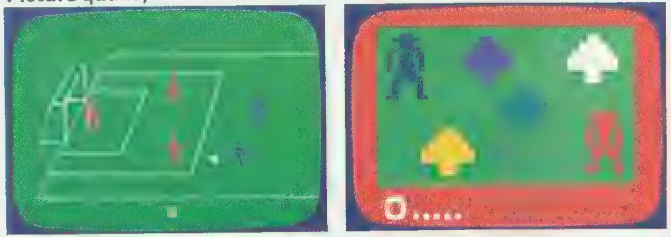




Each instruction from the computer controls the colour of a square group of dots called a pixel (short for picture element), so all the dots in one pixel are the same colour.

The dots are lit up by beams of electrons which scan the back of the television screen. The beams are controlled by the computer according to the instructions for each pixel.

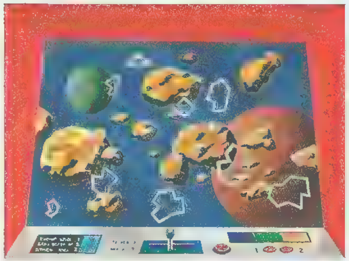
Picture quality



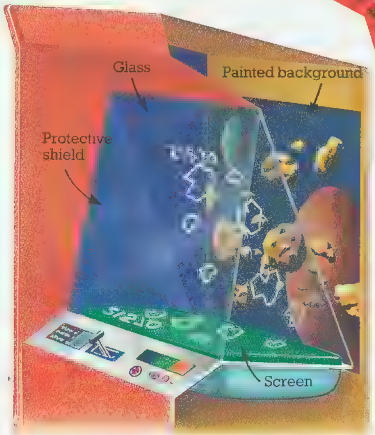
A detailed picture with perspective is made up of a large number of small pixels, whereas simpler, more stylized pictures have fewer, larger pixels. For instance, a picture like the one on the left is made up of about 30,000 pixels, and the one on the right has only about 2,000. To make detailed, realistic pictures the computer needs a large memory to store the instructions for all the pixels.

Special effects

The picture in an arcade game is made in the same way as a television picture. Some arcade games, though, use special effects to make the game more exciting.



For instance, in some games you see a reflection of the screen, rather than the screen itself, against a painted background. The painting has more detail than it is possible to create with a games computer.



Inside the game there is a sheet of glass positioned at an angle over the screen. The picture on the screen is upside down so that when it is reflected on the glass, it is the right way up. You can see the painted background through the glass.

How to win at

FROGGER

Here are a few tips for this game in which you score points by guiding a frog across roads and rivers to reach home safely.

Be careful to land accurately on logs and lily pads. If the frog is half on and half off it will fall in the river.

Watch out for the flashing green leaves. The frog will blow up if it lands on one of these. Watch out for the crocodile on the log line and the snake on the lilyleaves, too.

You get bonus points by jumping on a purple frog, eating insects, helping a lady frog home and jumping into holes containing the purple bird.

How to win at

SCRAMBLE

You are a spaceship commander on a mission over enemy territory. Your aim is to destroy the robot at the end of the maze and win a new mission.

It is crucial to watch your fuel level and to gain fuel by destroying fuel dumps. In the first, easy stretch of the mission, fly low and destroy as many dumps as possible. This should give you enough fuel to see you through to the end of the mission. It is easier to hit the targets by shooting from just above ground level than by bombing. When you are bombing, aim just in front of your target to allow for the angle of the bombs as they fall.

When you are under attack, try and dodge the attackers and shoot them down, but keep bombing the ground at the same time. Watch out for obstacles on the ground and be ready to take evasive action.

Making sound effects

The instructions for making the sound effects for a game are stored in the computer's memory. During a game, messages from the computer cause the loudspeaker to make the sounds.

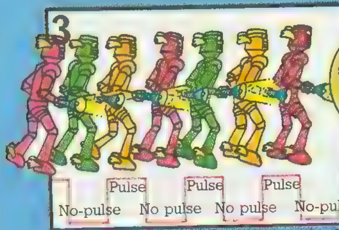
1 How sounds are made

Sounds from a loudspeaker set up invisible movements called waves in the air. When the waves reach your ears, messages are sent to your brain and you hear the sounds.

2

High sounds make rapid movements in the air and lower sounds make slower movements. To make sounds like this the computer has to make movements in the air using a loudspeaker. The rate of movement is called frequency. Simple sounds, which have only one frequency, are easy to make using the pulses of computer code. With the more complicated sounds the computer code has to be translated into a single current.

3



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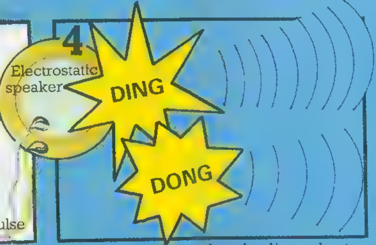
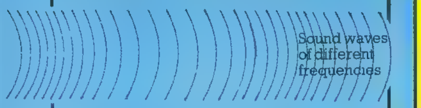


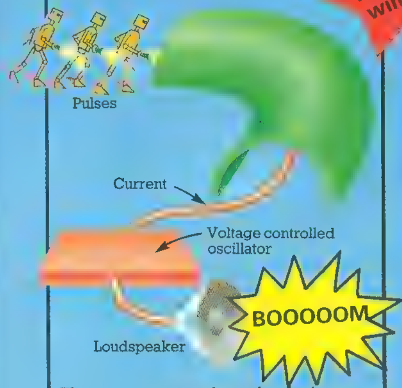
To make simple sounds, streams of pulses and no-pulses are sent from the computer's memory to an electrostatic loudspeaker. This consists of two flat discs stuck together. Each pulse is a small current of electricity and the change from pulse to no-pulse makes the discs vibrate. The vibrating discs make the air round them move, setting up a sound wave. Different patterns of pulses produce vibrations of different frequencies, and so produce different sounds.

Making explosions

More complicated sounds, such as explosions, contain sound waves of lots of different frequencies. The sound wave for an explosion might look like this.



To make sounds like this, the pulses of computer code have to be changed into a single current. The strength of the current varies depending on the patterns of pulses.



The current passes through a device called a voltage controlled oscillator and then on to a loudspeaker. The loudspeaker contains a cone of paper which vibrates and creates sound waves in the air at various frequencies according to the strength of the current.

How to win at

GALAXIAN

The aim of this game is to destroy aliens and their flagships. To get a high score, remember that aliens and flagships are worth double the number of points if you destroy them when they are attacking you than when they are in formation.

Flagships on the attack are worth the most points, so concentrate on them as soon as they attack. If the flagship has an escort, try to destroy it too.

While waiting for a flagship attack, destroy any attacking aliens then concentrate on the aliens still in formation. Aim at the aliens in the outside columns first to narrow their field of attack. In this game you cannot shoot very rapidly so you have to be careful to aim accurately.

How to win at

LUNAR RESCUE

In this game you are trying to rescue astronauts under fire from alien space vehicles.

In the first phase of the rescue the fire button operates your thrust control as well. Use thrust to avoid being hit by asteroids, but watch your fuel level. Be careful not to hit the flashing beacons as they will destroy you.

Try to land on the corner landing pads first. On your return to your ship destroy as many alien space vehicles as possible. You must enter the ship without touching the side of the door. If you do you drop the astronaut.

When the alien space vehicles are widely scattered expect a meteor shower and use the fire button to ascend to safety fast

Talking games

There are lots of games which can "speak" to you, but it is not yet possible to build a game which can understand spoken words. It is very difficult for a computer to understand the human voice as everyone speaks slightly differently. A very large computer, though, which has lots of memory, can be programmed to understand a few words.

Computers which can talk have all the words they can speak stored in binary code in their memories. Below you can find out how this works.

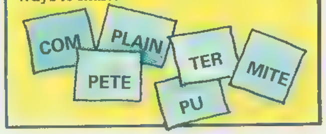
ROM cartridge with extra words for the computer to speak.

How a computer stores sounds

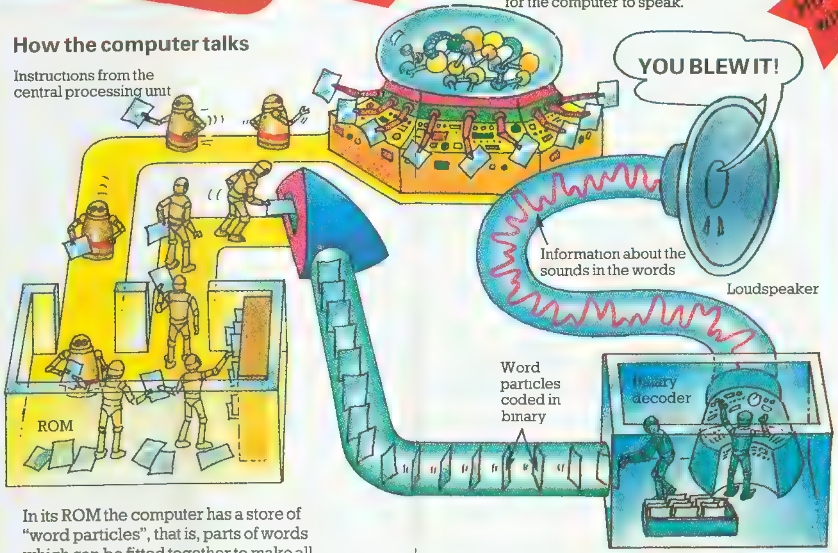
There are several different ways in which sounds can be stored, for instance, on record or tape. A computer, though, can store information only in binary code, and sounds, too, have to be coded in binary.

Most words contain several sounds created by the arrangement of the letters in the word. In order to speak, the computer has to store all the sounds for each word in its memory.

The easiest way to do this is to break the words up into word particles, for instance, com-pu-ter. Each word particle, for instance, "com", is represented by a different piece of binary code. The word particles can then be put together in lots of different ways to make different words.



How the computer talks


Instructions from the central processing unit
YOU BLEW IT!
Information about the sounds in the words
Loudspeaker
Word particles coded in binary
binary decoder
ROM

In its ROM the computer has a store of "word particles", that is, parts of words which can be fitted together to make all the words in the computer's vocabulary. The word particles are in binary code, along with rules telling the computer how to fit them together. Instructions from the central processing unit tell the memory which word particles to select. They are sent to a binary decoder where the binary code is translated into an electrical current. The strength of the current varies continuously and represents the changes in the sounds in the words. The current then goes to a loudspeaker which vibrates to create the correct sound waves for the words. Making a machine speak like this is called speech synthesis.

How to win at SWARM

In this game you have to destroy enemy spacecraft. You score more points if you hit the spacecraft while they are attacking. The small yellow spacecraft with its two red escorts is worth a lot of points, so shoot it down as soon as it appears. Do not try to follow the purple spacecraft though. They fly at acute angles and are difficult to hit. Be careful not to stay too long in the corners of the screen as you are liable to be trapped there.

How to win at PHOENIX

In this game you control a spaceship at the base of the screen. The game has five phases and the aim of the game is to survive the attacks by the birds in the first four phases so that you can destroy the alien spaceship and pilot in the fifth phase

In the first and second phases, fire at the birds before they break out of formation. They are easier to hit like this, although they are not worth so many points.

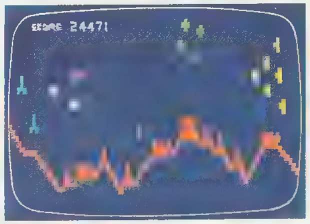
In the second phase you can fire more rapidly, so aim at the highest concentrations of birds and destroy them with continuous fire.

In the third and fourth phases, try and destroy the eggs before they hatch into birds which can drop bombs. If an egg hatches, you have to destroy the bird by hitting it full in the centre.

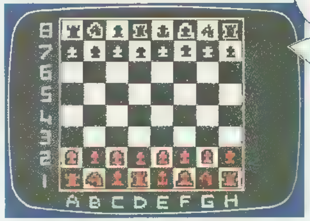
When the saucer appears, destroy all but one of its guard birds. If you destroy all of them, a new set appears. Then shoot a hole through the protective ring round the ship, and through the bottom of the ship, so you can get at the pilot.

Playing games with a microcomputer

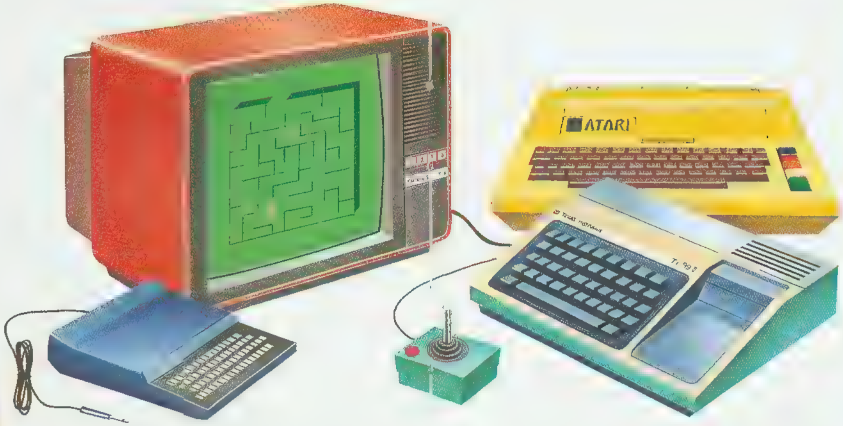
You can play any game you want on a microcomputer and you can invent your own games too. A micro has all the same parts as a computer game, except for the games program. You give a micro its program by typing on the keyboard, or by plugging in a prerecorded program from a ROM cartridge or cassette. You can find out more about this and about writing your own programs, over the page. Here there are some examples of the kinds of games you can play on a micro.



This is a version of an arcade game called Scramble which you can play on a micro. You can also buy programs for versions of Space Invaders, Missile Command and Asteroids to play on most micros.

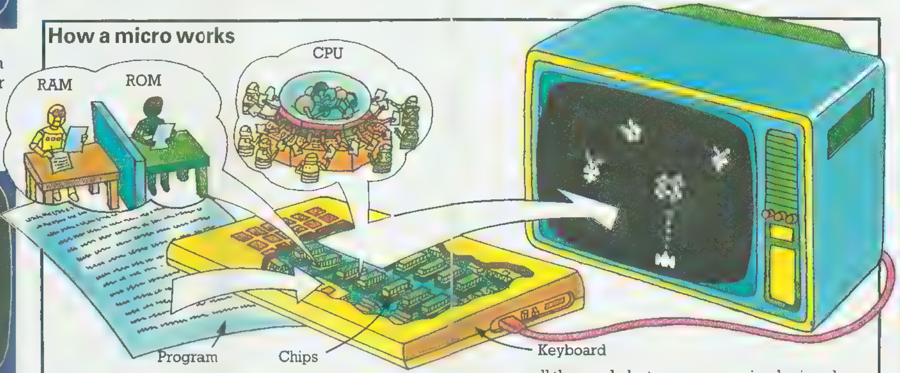


You can play chess on a microcomputer. The computer displays all its own moves and yours on the TV screen, and it can beat all but the very best players.



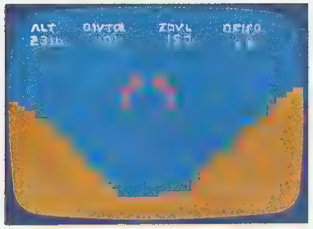
Most microcomputers consist of a keyboard which you plug into a TV set. The game, or any other program you give the computer, is displayed on the TV screen. The kind of games you can play depends on how much memory the computer has. A computer with a memory of 16K (K stands for kilobytes and one kilobyte is a thousand bytes), can cope with complex games such as chess and imitation arcade games. With a smaller memory of 4K to 6K you can play quite reasonable games and with a memory of 1K you can play only very simple games. You can buy extra memory for some micros.

How a micro works

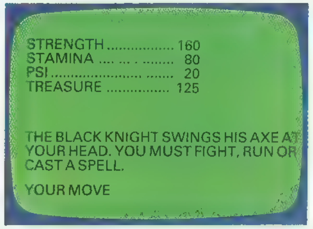


Like all other computers, a micro is made up of chips and has a central processing unit (called CPU for short), a permanent memory (ROM) and a temporary memory (RAM). Some micros have as few as four chips to do all the work, but an average sized micro has a printed circuit board similar to that in an arcade game.

In a micro, the ROM contains instructions telling the micro how to work, and the programs you give it are stored in the RAM.



This is a game called lunar lander in which you have to land a space ship safely on the moon, taking into account how much fuel you have and the velocity and drift of the ship.

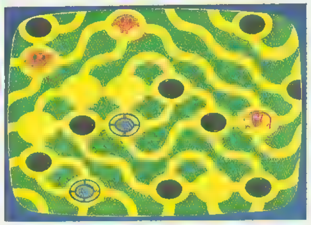


STRENGTH 160
STAMINA 80
PSI 20
TREASURE 125

THE BLACK KNIGHT SWINGS HIS AXE AT YOUR HEAD. YOU MUST FIGHT, RUN OR CAST A SPELL.

YOUR MOVE

This is an "adventure game". The computer describes a hazardous adventure in words on the screen and asks you what you want to do at various stages. Your decisions affect what happens to you in the adventure. There are lots of different kinds of adventure games. Some are very complex, needing large computer memories and often taking weeks to solve.



This is a maze game in which you have to catch a creature in a maze inhabited by bats, beasts and other hazards such as slime pits.

Micro games

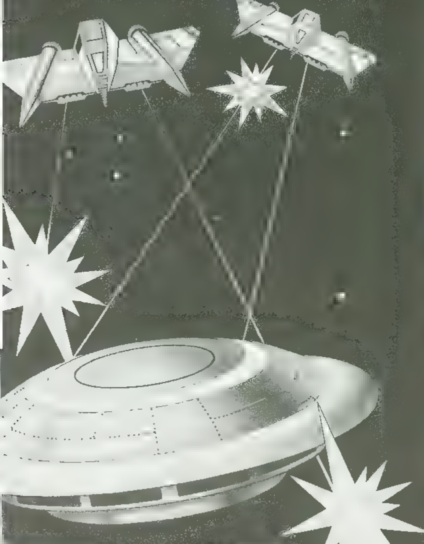
Programs for microcomputers have to be written in a special language which the computer can understand. Most micros use a programming language called BASIC, which is fairly easy to learn. Below there is an example of a simple games program written in BASIC.

You can also buy programs printed in magazines and books, as well as recorded on cartridges and cassettes. Different makes of micro, though, use slightly different versions, or dialects, of BASIC, so when you buy a program, make sure it is suitable for your computer.

Computer program

This is a short program for a space game to play on the ZX81 computer.* You can find out how to play the game, and how the program works, on the opposite page.

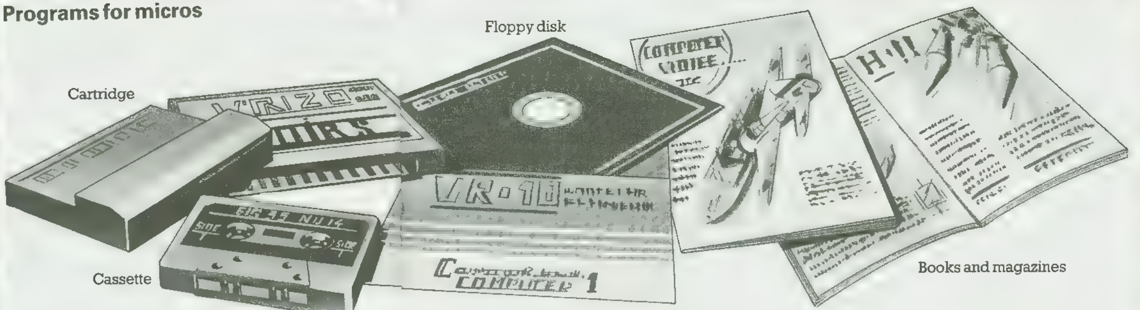
In this game you are the gunner in a starfleet battle-cruiser. You come under attack from alien fighter craft and have to defend your convoy of supply vessels.



```
100 LET A=0
110 LET S=0
120 IF A=20 THEN GOTO 270
130 CLS
140 PRINT "NUMBER OF HITS–";S
150 FOR D=1 TO 30
160 NEXT D
170 LET P=INT(RND*26)+1
180 PRINT AT 10,P;" XXX "
190 PRINT AT 11,P;"<$$$>"
200 PRINT AT 12,P;" XXX "
210 LET A=A+1
220 LET T=INT(RND*40)+1
230 FOR B-1 TO T
240 IF INKEY$<>"" THEN GOTO 290
250 NEXT B
260 GOTO 120
270 PRINT AT 20,0;"YOU HIT–";S;
    " -ALIENS IN 20 ATTACKS"
280 STOP
290 LET S=S+1
300 GOTO 120
```

Leave spaces here

Programs for micros



For most micros you can buy cassettes and cartridges of games (and other programs) made specially for them. A cartridge slots into the computer, like a TV game cartridge. With a cassette you have to connect the micro to a cassette recorder, then, when you play the cassette, the program is loaded into the computer.

You can also buy programs on floppy disks. For these you need an extra piece of equipment called a disk drive.

If you write your own programs you can store them on blank cassettes, or floppy disks. The computer can transfer programs on to cassettes or disks, via the cassette recorder or disk drive.

Programs from books and magazines have to be typed very carefully into the computer keyboard. This can take a long time and if you make any mistakes the computer will not run the program until you correct them. Typing in programs, though, is a good way of getting to know BASIC and seeing how programs work.

How the program works

Each of the lines in the program is numbered and the computer carries out the instructions in order.

The letter A stands for the number of attacks and S for your score. Lines 100 and 110 set A and S at zero to start the game. Line 140 tells the computer to display your number of hits on the screen.

Lines 150 and 160 make the computer count to 30 so that it pauses before starting the game.

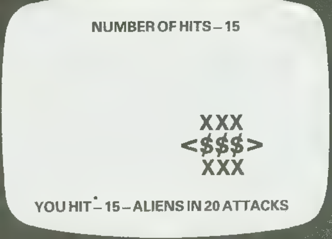
Line 170 tells the computer to pick any number between 1 and 26. This number gives the position for the fighter craft on the screen. Lines 180 to 200 make the picture for the alien fighter craft.

Line 210 keeps count of the number of attacks. Line 220 tells the computer to pick another number to give the time that the fighter stays on the screen. Lines 230 to 250 check to see if you hit the fighter in this time.

Lines 260 to 300 send the computer back to the beginning of the program for another attack. If you hit the fighter line 290 adds one to S for the score.

How to play

First you have to type each line, exactly as it is written here, into the computer. Remember, this program works only on the ZX81 and ZX Spectrum. Then you press RUN to tell the computer to carry out the program.



```
NUMBER OF HITS – 15

                         XXX
                        <$$$>
                         XXX

YOU HIT – 15 – ALIENS IN 20 ATTACKS
```

The computer will display the shape for a fighter somewhere on the screen. To "hit" it you have to press any key on the keyboard. For each attack, the position of the fighter and the time you have to hit it are different. At the end of the game the computer displays your score on the screen.

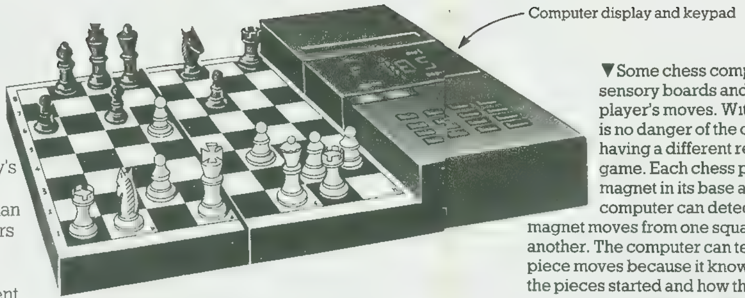
---

*It works on the ZX Spectrum, too.

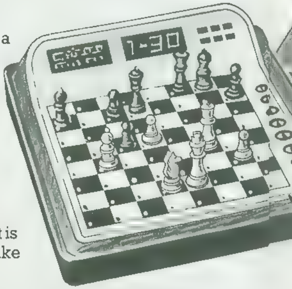
Chess computers

A chess computer is a dedicated computer which is programmed to play only chess. People have been writing programs for computers to play chess since the first electronic computers were built in 1940. Today's chess computers, though, are more powerful and have more memory than the scientific computers of forty years ago, and some can beat all but the very best players.

In fact, people were trying to invent a machine which could play chess over two hundred years ago, before computers were even invented. These two pages show the first chess machines and some chess computers of today. You can find out how a computer plays chess over the page.



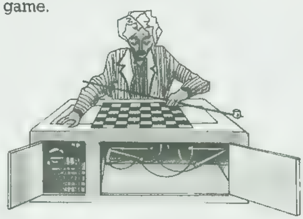
▲This chess game has a computer with a keypad for entering the player's moves and a display to show the computer's responses. The player has to be careful to type moves in accurately, or the computer's record of the game will be different from the game on the board. This is sometimes discovered only when the computer will not accept an apparently legal move.



►This game has a built-in voice synthesizer and can speak its moves. It works like the talking games on pages 22-23. As well as telling you its moves it will also remind you that it is your turn if you take too long.

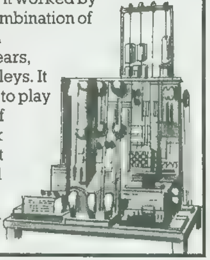
First chess machines

The first known chess machine consisted of a chess-board and a cabinet containing a complicated set of levers and gears. Seated at the cabinet was a model of a man in Turkish dress and the machine was called The Turk. It was invented in 1769 and rapidly became famous throughout Europe and America, as it could defeat most of the players who challenged it to a game.

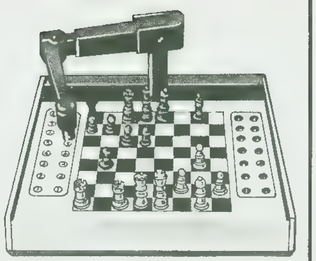


The Turk is now believed to be a very clever hoax. It did not compute the chess moves itself, but had a human player hidden in the cabinet who detected his opponent's moves with magnets. The Turk was destroyed in a fire over 100 years ago.

The next chess machine appeared in the 1890s. It was an electro-mechanical device, that is, it worked by means by a combination of electricity and mechanical gears, levers and pulleys. It was designed to play an endgame of King and Rook against King. It always played White – and always forced checkmate.

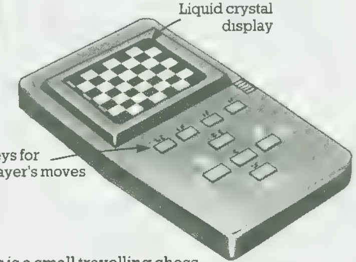


▼Some chess computers have sensory boards and can "feel" the player's moves. With these there is no danger of the computer having a different record of the game. Each chess piece has a magnet in its base and the computer can detect when a magnet moves from one square to another. The computer can tell which piece moves because it knows where all the pieces started and how they have moved since then.



▲The robot arm on this chess-board makes all the computer's moves, and removes your pieces when the computer captures them. If the computer loses the game, it flings its arm about, flashes its lights and shrieks.

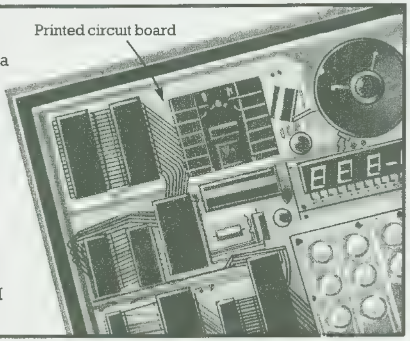
The computer signals its moves by flashing lights in the squares and you move the pieces for it.



▲This is a small travelling chess computer. It has a liquid crystal display so you do not need chess pieces. The moves are displayed in chess notation and the liquid crystal display is controlled by pulses from the game's microprocessor.

Inside a chess computer

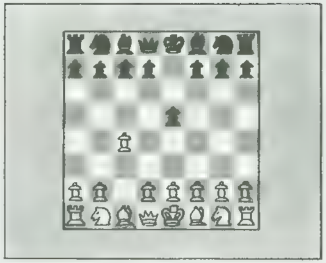
Inside a chess computer there is a printed circuit board with all the usual chips. The program telling the computer how to play the game is stored in the ROM chips. All the moves are worked out in the microprocessor chip, based on information from the ROM. The RAM chips provide extra work space for the computer to use while it is calculating its best move, and the moves made during a game are stored in RAM too.



How computers play chess

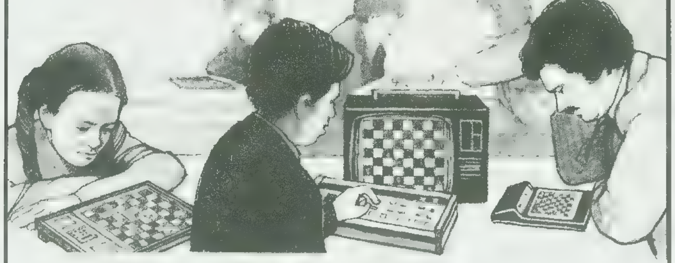
All the information a computer needs to play chess is stored in its ROM memory. An average chess computer has a memory size of about 12K and a very powerful chess computer may have about 200K of memory. The information in the ROM consists of the rules of the game and the way the pieces move, strategies to follow at different stages in the game and book openings.*

The computer chooses each of its moves by analyzing a number of the possible moves and choosing the best. The number of moves the computer can test depends on the size of its memory. Even a very powerful chess computer cannot test all the possibilities, though. There are over 300 million for the first three moves alone.



At the start of the game the computer loads the positions of all the pieces into its RAM. Then, for its first few moves it may follow a book opening. When the positions of the pieces begin to differ from those of the book opening, the computer abandons the opening and begins to analyze each move.

Computer chess championships

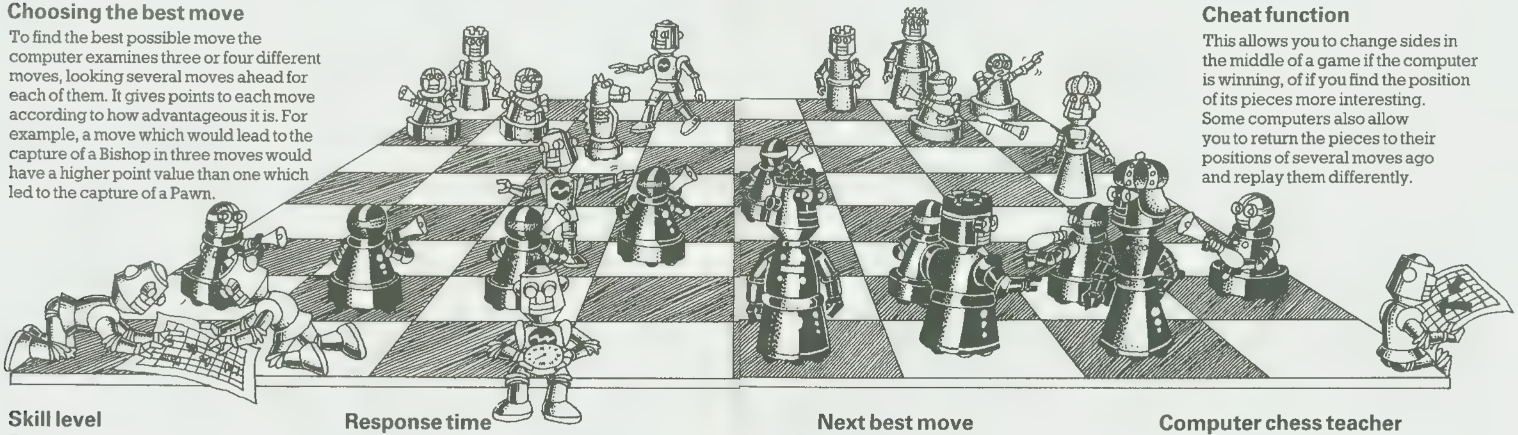


Each year chess tournaments are held in which people play against computers and computers compete against each other. The title of champion chess computer is at present held by a computer called Belle which has a very high chess rating of 2,400 points (U.S. rating). Belle can examine 160,000 possible positions every second and contains over 1,700 chips.

In the near future all chess computers will probably be given ratings according to how well they play, in line with the ratings given to human players. The ratings are worked out by giving each computer points for the number of times it wins or draws in a fixed number of games against other rated players.

Choosing the best move

To find the best possible move the computer examines three or four different moves, looking several moves ahead for each of them. It gives points to each move according to how advantageous it is. For example, a move which would lead to the capture of a Bishop in three moves would have a higher point value than one which led to the capture of a Pawn.



Cheat function

This allows you to change sides in the middle of a game if the computer is winning, of if you find the position of its pieces more interesting. Some computers also allow you to return the pieces to their positions of several moves ago and replay them differently.

Skill level

The number of moves the computer can look ahead is limited by the size of its memory. Each move by Black or White is called a ply, and a powerful chess computer can make a nine ply search. On most chess computers you can set the skill level at which the computer plays by limiting the number of moves it examines.

Response time

The time the computer takes to choose its move varies according to which skill level it is playing on, and how many moves ahead it is looking. When playing at an advanced level, some computers can take four or five hours to decide their next move, or until you tell them to stop.

Next best move

With some chess games you can ask the computer what its next best move would have been, and some will tell you up to eight other moves that they were considering. Another way of limiting the computer's skill is to instruct it to play its second best move, rather than the one with the highest point value.

Computer chess teacher

Most chess computers can play games against themselves and some also have the games of famous players stored in their memories and can play them for you to watch. They can also set you chess problems to solve and can indicate how the computer would have solved them.

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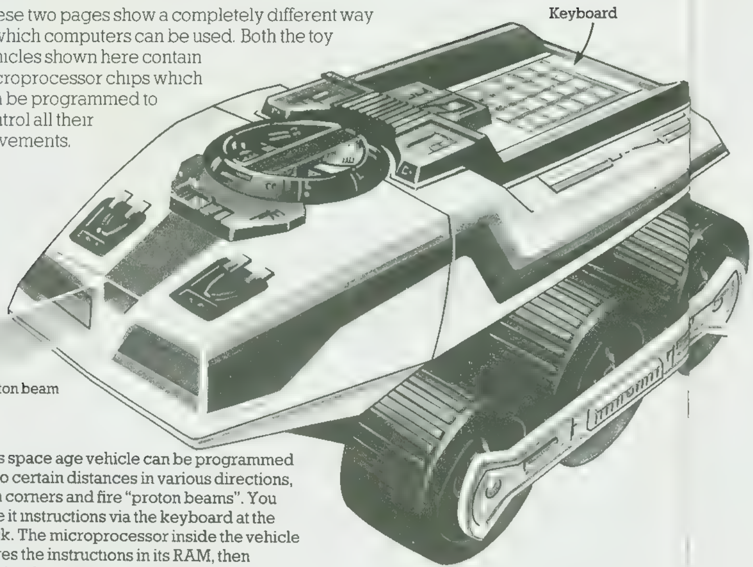
*A book opening is a standard set of moves which can be followed in the first part of a game. Some computers hold over forty different openings.

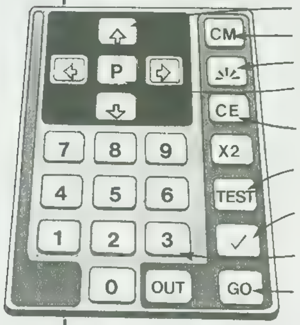
Computers on the move

These two pages show a completely different way in which computers can be used. Both the toy vehicles shown here contain microprocessor chips which can be programmed to control all their movements.



This space age vehicle can be programmed to go certain distances in various directions, turn corners and fire "proton beams". You give it instructions via the keyboard at the back. The microprocessor inside the vehicle stores the instructions in its RAM, then carries them out in the correct order.

The computer keyboard



Direction keys

Clears old instructions from the computer's memory.

Tells the computer to fire a proton beam.

Instructs the computer to hold the vehicle stationary for a few seconds.

Key for correcting mistakes. It wipes out the last instruction from the computer's memory.

Makes the vehicle carry out a short test sequence of movements which it holds in its ROM.

Tells the computer to carry out your last instruction so you can check that it makes the vehicle do what you intended.

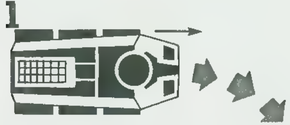
Distance keys. The figures represent the number of times the vehicle should travel its own length.

Key to tell the computer to carry out the program after it has received all the instructions.

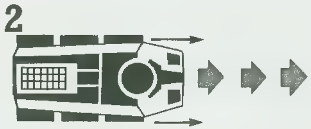
When you type in a program you have to tell the vehicle which direction to go (forwards, backwards, left or right) and how far to go. Distances are measured by the number of times the vehicle travels its own length, and this unit of measurement is held in the computer's ROM.

How the computer steers the vehicle

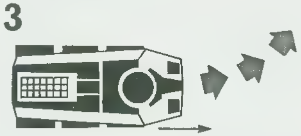
The vehicle's tracks are powered by an electric motor. The computer can switch the motor on and off with electrical messages, and so control the supply of power to the tracks.



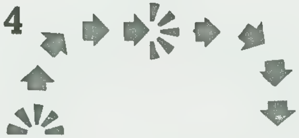
To turn the vehicle to the right, power to the right track is switched off. The drive from the left track pushes the vehicle round to the right.



If the right track is started up again, both tracks are pushing equally and the vehicle carries on along a straight path.

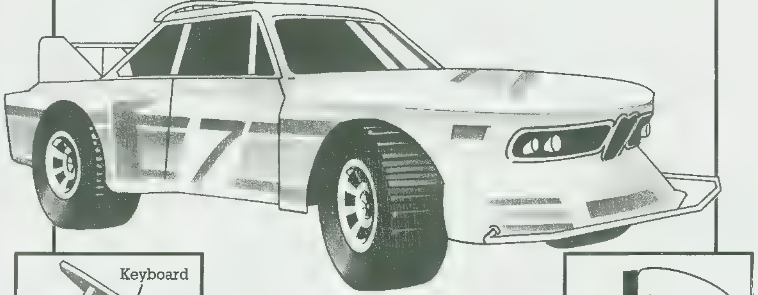


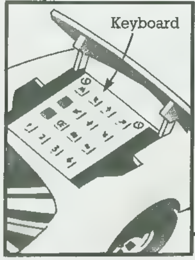
When a message from the computer switches off the power to the left track, the vehicle swings round to the left.



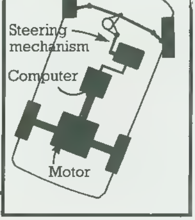
In a program of instructions, sequences of messages drive the vehicle in various directions and fire the proton beam.

Programmable car





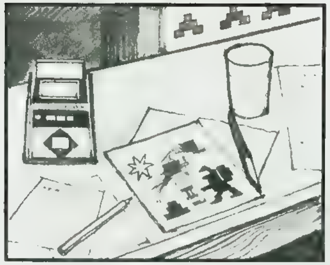
This car has a keyboard under the bonnet for programming the microprocessor. The computer can be programmed to sound the car's horn and control how far it goes in various directions. Messages from the computer control the steering mechanism on the front wheels and the motor which drives the back wheels.



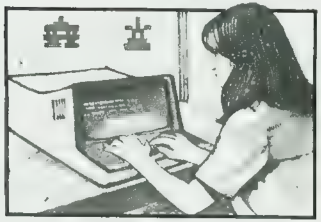
How a game is made

Electronic games, arcade games and even the games you write for a microcomputer are all developed in much the same way. First you need an idea and a story setting for the game. Then you have to translate it into a computer program. With a home computer you can then type the program into your micro, but electronic and arcade games have to have the program built into their chips.

A game idea may start off as an arcade game, then a hand-held or TV version may be developed under licence to the original manufacturer.



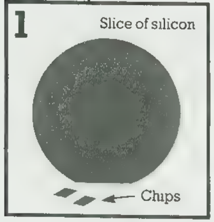
The first stage in the development of a game is to make a detailed plan of the game and work out the rules and scoring system. A graphic designer will make sketches for the display and the characters in the game.



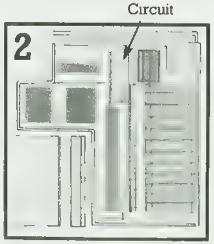
Then a computer program is written with instructions telling the computer exactly how to play the game. The program is written in a computer language and then each instruction is translated into the computer's code of 1s and 0s.

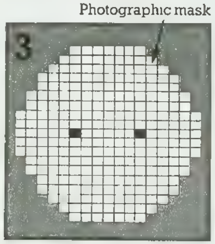
An electronic engineer designs circuits to produce pulses and no-pulses in the same patterns as in the program of 1s and 0s. The circuits are then built into a special chip so that they can be tested and altered if they are not correct.

How chips are made

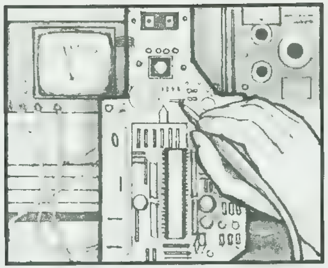


The silicon from which chips are made is very pure crystal. It can be treated so that it conducts current through precise pathways in the silicon. One slice of silicon will make over a hundred chips.

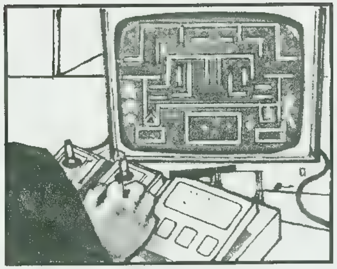




The circuits for the chips are drawn up enlarged over two hundred times, then reduced to chip size and repeated lots of times on photographic masks which will fit over the slices of silicon.

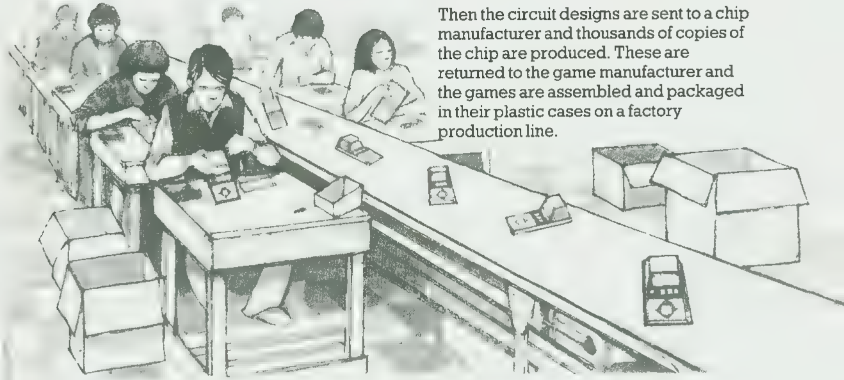


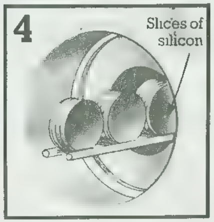
Then the test chip, which is called an EPROM (Erasable Programmable Read Only Memory), is assembled on a printed circuit board with the other components of the game such as the display and player's controls.

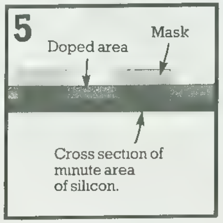


The game is tested to make sure that the circuits on the chip are producing the correct patterns of pulses and the computer is playing the game correctly. If the game is not working perfectly, the circuits are checked and altered.

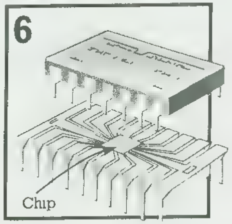
Then the circuit designs are sent to a chip manufacturer and thousands of copies of the chip are produced. These are returned to the game manufacturer and the games are assembled and packaged in their plastic cases on a factory production line.







The slices of silicon are then doped with impurities under great heat. This creates pathways which will conduct electricity in the parts of the silicon which are not protected by the mask.



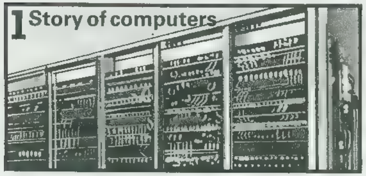
This process is repeated several times to produce layers of circuits in the surface of the silicon. Then the silicon slices are cut up to make the chips, and each chip is packaged in its case.

Story of computer games

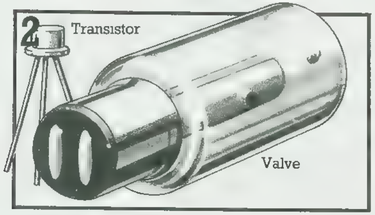
The story of computer games is closely linked to the story of computers themselves. The first electronic computers were made in the 1940s. They were vast and not very powerful machines. During the next twenty years, though, several new inventions which led to the silicon chip, enabled much smaller, more powerful computers to be built.

The new computers could be used to control all sorts of equipment, including computer games. The first electronic games were made in the early 1970s.

1 Story of computers

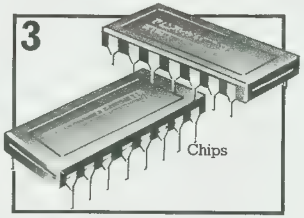


The first electronic computers were vast room-sized machines. They had very small memories and carried out their calculations very slowly compared to present-day computers. They were invented to help crack enemy codes in World War II and track the positions of enemy planes from radar reports.

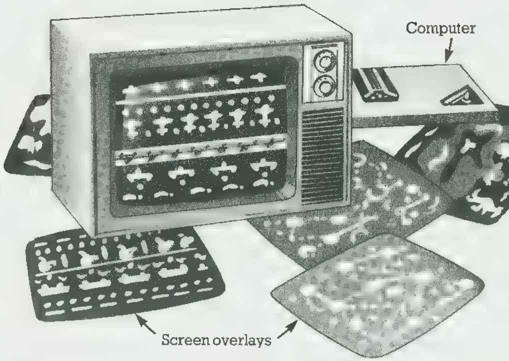


The early computers used components called valves to control the pulses in the computer. In 1947, a new component called a transistor was invented. Transistors do the same work as valves, but are much smaller. In the 1950s, smaller computers with much more computing power were built using transistors.

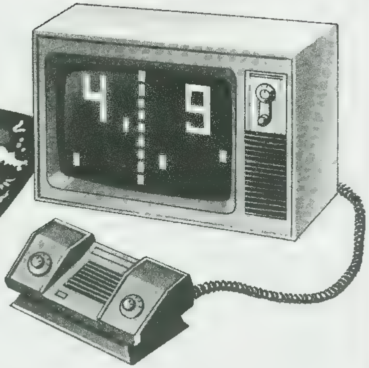
▲This is Computer Space, the first video arcade game. It was made in 1971 and the game was a dogfight between a flying saucer and a spaceship. It had a very simple black and white screen picture and was housed in a black fibreglass case. Computer Space was invented by Nolan Bushnell, the man who founded Atari which is now one of the biggest video games companies.



In 1960 the first silicon chips were made. The circuits on a single chip could do the work of thousands of transistors, and as the new technology improved it became possible to fit a whole computer on a single chip.

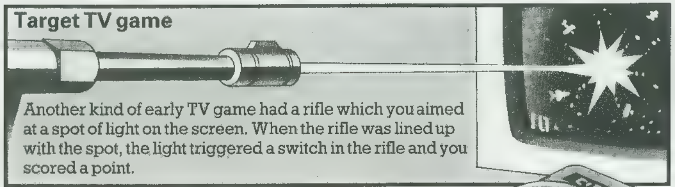


▲The first TV game was made in 1972 by a company called Magnavox. It had a computer with player's controls and some coloured overlays for the TV screen. The computer could make only a spot of light on the screen and you created different games with the screen overlays.

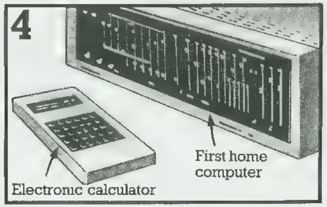


▲This is Pong, the first TV game made by Atari in 1975. It was a simple, black and white bat and ball game. Pong's computer was a dedicated computer – it could play only Pong. It was followed by Super Pong which could play four different bat and ball games.

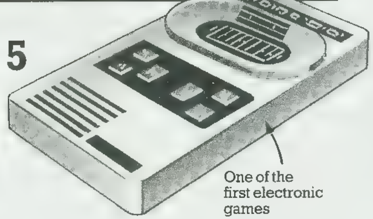
Target TV game



Another kind of early TV game had a rifle which you aimed at a spot of light on the screen. When the rifle was lined up with the spot, the light triggered a switch in the rifle and you scored a point.



In 1971 the first portable home computer was built, using silicon chips. Around the same time, pocket-sized electronic calculators appeared, with their own built-in electronic display. These paved the way for the first hand-held electronic games which appeared a few years later.

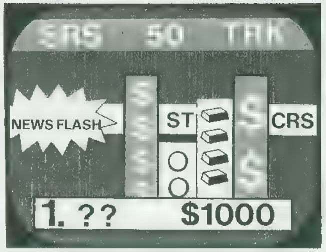

5
One of the first electronic games

The first hand-held electronic games appeared in 1976. They contained a computer on a chip and had their own built-in electronic display. Two of the first games were Football and Autorace made by Mattel.

Useful games

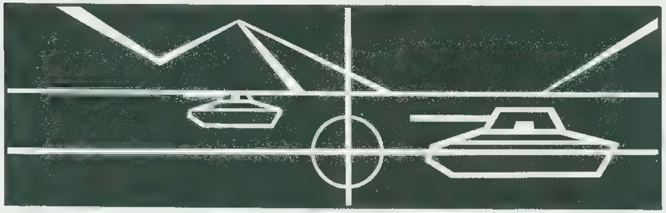
Most games are used for entertainment only, but computer games can be built round real situations and used as learning aids. Some computer games can also teach you a subject, such as maths, as you play the game.

The way a computer reproduces all the features of a situation is called computer simulation. A computer can simulate, say, the economy of a country, or even a battle, by being programmed with real, rather than invented data. Here are some types of computer games which can be used in other ways than just for entertainment



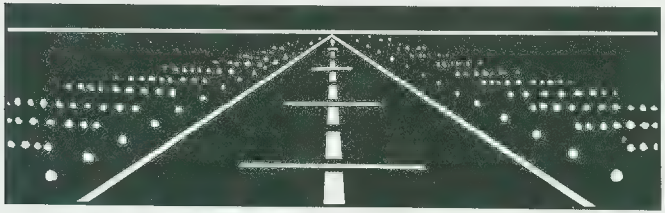
This is a computer game based on the workings of the stock exchange. Players buy and sell gold and stocks and shares and the computer keeps track of all the investments.

Target practice simulation

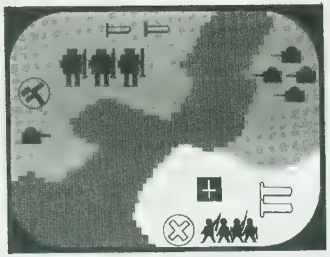


This is a video game made specially for the U.S. Army. It is based on an Atari game called Battlezone, and shows the player's view from a troop transport vehicle. The simulated landscape and enemy tanks get larger and smaller as the player's vehicle moves towards and away from them. The player has to line up the tanks in the sights and shoot them. The firing controls include telescopic sights and missile tracking devices and the computer can set target identification problems.

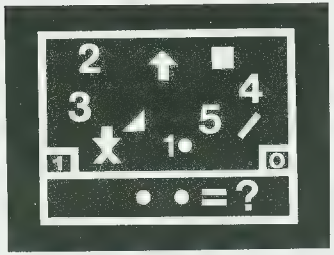
Flying practice



In this simulation the computer creates a pilot's view of an airport runway. Although not strictly a game, it uses some of the same principles to give trainee pilots flying practice. The pilot has a set of simulated aircraft controls and as he or she brings the plane in to land, the view from the cockpit changes. Simulations like this are also used to train people to navigate oil tankers and drive cars.



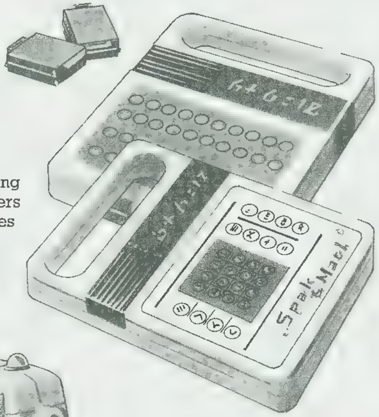
This game is a simulation of a battle. The players can choose their method of attack and the size and position of their forces. Simulations like this are used by military planners to test their theories and strategies.



This is a TV game for children to improve their arithmetic. The players have to catch the correct object or number to complete the equation and they score points for correct answers.

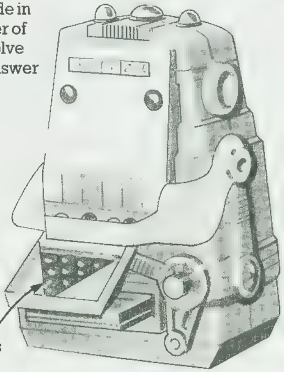
Learning games

In these electronic games the computer tests your general knowledge, or helps you learn a new subject.



▶ Speak and Spell and Speak and Maths are two talking games for learning spelling and arithmetic. Their computers set problems to solve, and create games such as code-breaking games and a version of hangman.

▼ Little Professor is one of the earliest electronic learning games. It was first made in 1976. It poses a number of problems for you to solve and tells you if your answer is right or wrong.



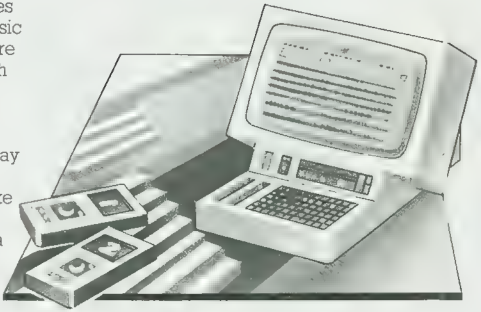
◀ This robot asks you general knowledge questions and recites riddles and jokes. It is called 2XL. The multiple choice questions are recorded in cartridges and if you get stuck, the robot will give you more information, or play music while you think. You tell the robot which answer you think is correct by pressing the buttons on the front of it.

Future games

Within ten years the computer games of today will probably seem very basic and primitive. The games of the future will be faster and more exciting, with superbly realistic screen displays.

These games will contain computers a hundred times more powerful and faster than those of today and capable of storing millions of pieces of information. Computers like these will be built by packing more and more complicated circuits into a chip of silicon.

Here are some of the features we might see in computer games in the not too distant future.



Powerful computers will be able to create adventure games infinitely more complex than those you can play on a micro today. To help the human player there will probably be a board and counters to plan and keep track of their moves.

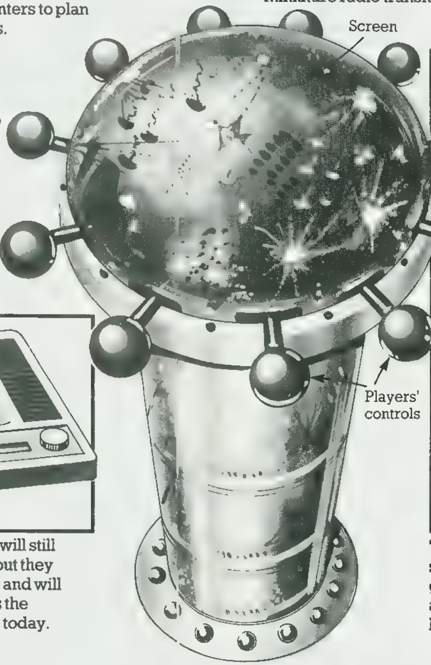
TV games

A TV game with a very large memory will be able to reconstruct detailed pictures of say, the Battle of Waterloo or a space battle, and the players will be able to control far more of the details in the picture than they can today.

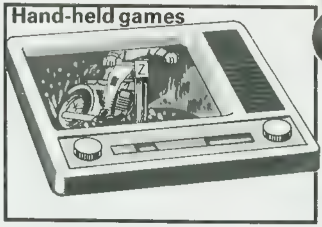
In TV sports games you will probably be able to control each of your team members individually. These games will also have electronically synthesized voices and the referee will tell you when you are offside or given a free kick.

Multiplayer game ►

At present, most computer games are for only one or two players. More powerful computers though, will be able to cope with instructions from a number of people playing at the same time, either as teams against each other, or against the computer.

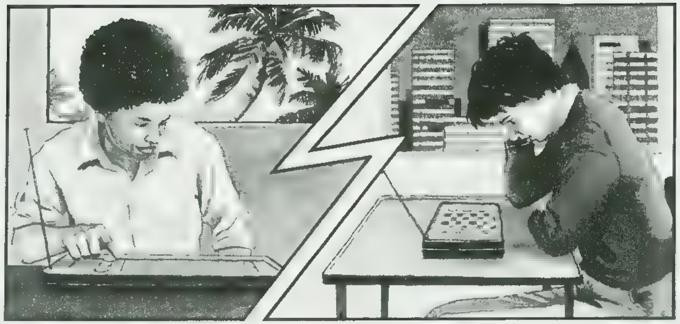


Hand-held games



Hand-held electronic games will still have liquid crystal displays, but they will probably be in full colour and will be as detailed and realistic as the pictures for a TV programme today.

Long distance game



By the year 2000 you will be able to challenge someone hundreds of miles away to a game. The games will contain miniature radio transmitters and receivers which will transmit your moves and receive those of your opponent with very little time delay. Your opponent's moves will be automatically carried out in the liquid crystal display.

The ultimate game

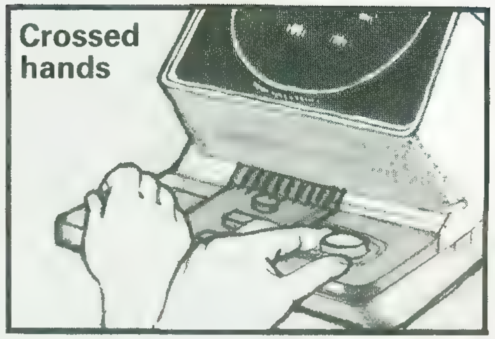
The ultimate game will be a super-realistic computer simulation which takes place all around you in a special games cubicle. The game, perhaps a space invasion or adventure game, will have three dimensional effects, laser lighting and quadrophonic sound.

Game variations

Here are some ideas for different ways to play electronic games to make them more difficult, or to play them with more than one person. Most of these ideas will also work on arcade games, if you do not mind losing some money.

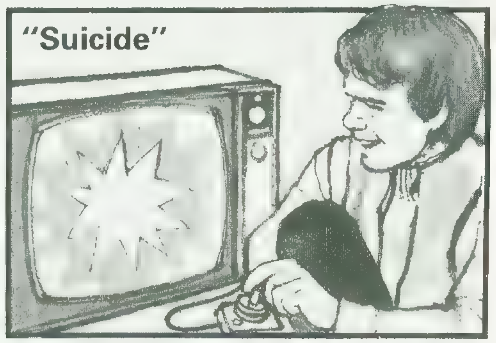
"Survival"

In this game you play to survive, not to win points. If you are playing against other people, the person who survives the longest is the winner. If anyone gets too good at the game, make them play with their hands crossed.



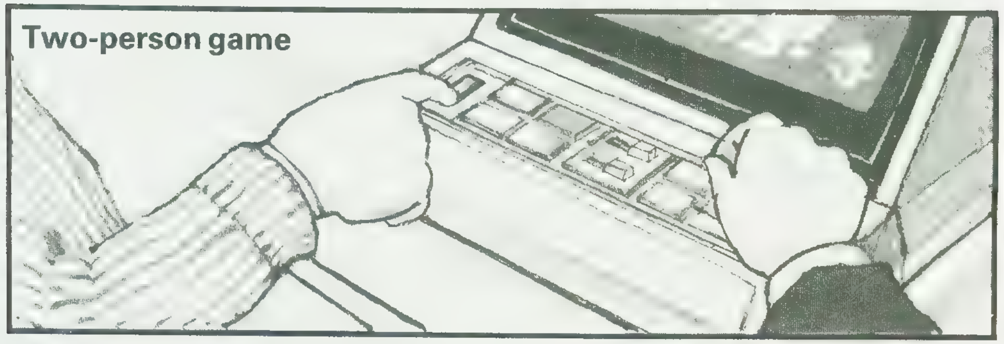
Crossed hands

To make a game more difficult, try crossing over your hands, so the hand you usually fire with is on the other control. This is quite tricky, so play the game on the easier skill level first.



"Suicide"

This is the opposite of the survival game. The object is to see who can finish the game the fastest with the least number of points.



Two-person game

With two people playing the same game, one can be in charge of the firing button and the other can move the laser base, or whatever controls the game has.

Alternatively, one person can be in charge of all the controls and the other can watch the display and tell them what to do. You have to have very fast reactions to succeed in this game.

How to win at SPACE INVADERS

Lots of people have worked out their own strategies for this well known game in which you have to destroy flying saucers and advancing columns of invaders to score points.

The flying saucers are worth the most points, so as soon as one appears, you should try to hit it. Each saucer is worth anything from 50 to 300 points. When you hit a saucer the computer picks a random number between these two figures for your score.

While you are waiting for the saucer, try and destroy the two outermost columns of invaders. The invaders move from side to side across the screen and each time they reach the edge, they advance down the screen towards your laser bases. By destroying the outermost columns of invaders you increase the time they take to reach the edge, so they also move down the screen more slowly.

You should also try and destroy all the invaders in one column, so that you have a safe place from which to shoot at the saucers. If you do not have an open column, you have to use one of your laser bases as protection. You can either hide behind it and dart out when you see a saucer, or shoot a hole through it and fire at the saucer through the hole.

Each time you destroy all the invaders, a new set appears lower down the screen. In order to keep the game going after the third new set of invaders, ignore the flying saucers and concentrate on destroying the invaders before they reach your laser bases.

How to win at STRATOS

The aim of this game is to destroy spaceships and aliens. There are four different phases in the game. Here are some tips to help you in each phase.

In the first phase, watch out for three spaceships peeling off from the top of the screen and try to destroy them. In the second phase, stay to the left of the screen, but watch out for stray bombs.

Play the third phase firing fast. Destroy the centre columns of birds first, and hit each bird twice to destroy it and the aliens it is carrying. Take the fourth phase slowly and try to destroy blue birds to gain bonus points and also to destroy any aliens that may be attacking you from below.

How to win at FIELD GOAL

In this game the aim is to gain points by destroying your opponents. You get bonus points each time you eliminate a complete line of players. Here are some other tips for scoring bonus points.

Try and break through the red and yellow lines as soon as possible, but be ready for the ball returning very fast after a breakthrough. Try also to hit the footballer as soon as possible after he appears.

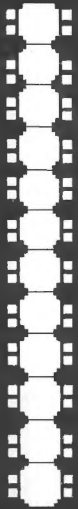
When you reach a score of 5,000 you receive a bonus ball. This ball attaches itself to your "foot" and stays with it while you take aim. If you catch this ball when it returns, it will again attach itself to your foot. If you fail to catch it, it will return to normal and bounce off your foot as soon as it makes contact.

Spot the video creatures

Can you identify these video creatures and symbols? The games in which they appear are listed at the bottom of the page, and for some of the games there are two or three creatures. Do you know which creatures belong to which game? The answers are on page 48.

Did you know?

Space Invaders was first invented in 1978 by the Japanese company Taito. It is said that by the summer of 1979, the Japanese mint had to make more 100 yen pieces as there were not enough in circulation for the game.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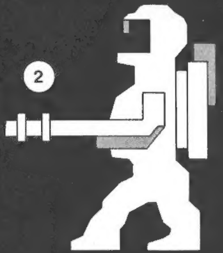
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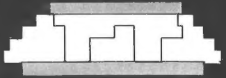
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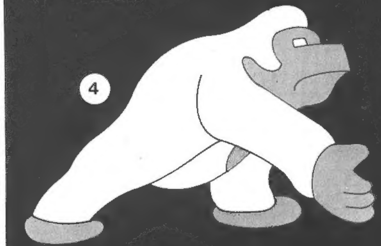
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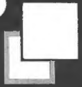
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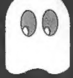
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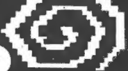
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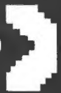
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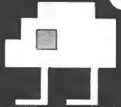
The creatures appear in the following games: Galaxian, Defender, Space Invaders, PacMan, Wizard of Wor, Tempest, Battlezone, Cosmic Avenger, Donkey Kong.

Record breakers

Four students have just broken the world record for Asteroids. They played for eight days in shifts and scored over 100 million points.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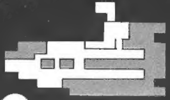
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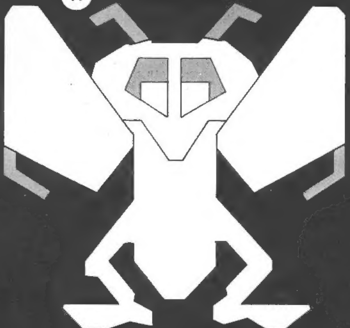
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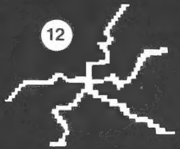
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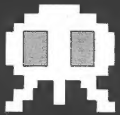
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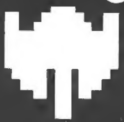
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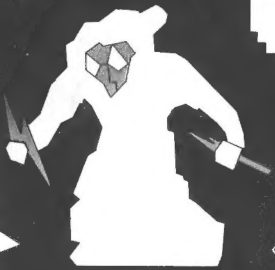
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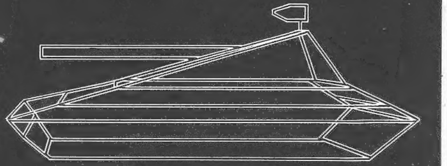
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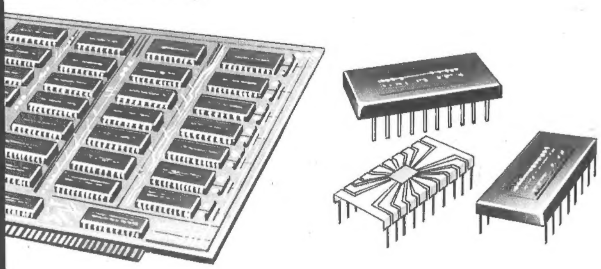
Why computers are good at games

A computer is a difficult opponent to beat. It never makes mistakes, it never gets tired or loses its concentration and it "thinks" extremely quickly. A human player may take the best part of a second to make and carry out a decision, say on how to defend a laser base. Each time, the player has to recall the rules of the game, judge how to apply them in this situation, then react with their hands. The computer can make a decision and carry it out almost simultaneously.



The computer's skill lies in the design of its electronic circuits. The pulses of electricity which do all the work in the computer travel through the circuits at the rate of millions of pulses a second. This enables the computer to make millions of decisions every second. It is also impossible for the computer to make a mistake, unless there is an electrical failure or the batteries are flat. The instructions for every single action carried out by the computer are built into its chips and have been tested and retested to make sure they are correct. Another strength of the computer is its ability to remember every move you make, as well as its own moves. All this information is stored in its electronic memory, coded in binary code, and can be recalled in a fraction of a second.

Despite all this, there is still no computer which can beat the very best players at chess. This is not due to the limitations of the computer though, but to the design of the program worked out by a human computer programmer. The real skill of a computer lies in the speed and accuracy with which it can carry out instructions given it by human game designers.

Books about computers

If you want to find out more about computers, how they work and what they can do, here are some suggestions for more books you might like to read.

Usborne Guide to Computers by Brian Reffin Smith, Usborne 1981
The Computer Book by Robin Bradbeer, Peter De Bono and Peter Laurie, BBC 1982
Illustrating Computers by Colin Day and Donald Alcock, Pan 1982
Introducing Computers by Ron Condon, Macdonald Guidelines 1981
The Mighty Micro by Christopher Evans, Coronet 1980
The Challenge of the Chip by W. H. Mayall, HMSO 1980

Computer words

BASIC The name of one of the languages used for writing computer programs. The letters stand for Beginner's All Purpose Symbolic Instruction Code. It is the most popular language for writing programs for a microcomputer.

Binary A number system based on only two digits: 0 and 1. The code used by computers is composed of binary numbers.

Bug A mistake in a computer program that stops it from working properly.

Byte A group of eight binary digits which usually represents one piece of information in computer code.

Cartridge A plastic case inside which there is a ROM chip which holds all the information telling a computer how to play a game.

Chip Popular name for a silicon chip, a minute slice of silicon containing electrical circuits.

Central processing unit (CPU) The control centre of the computer where all the work is done.

Computer A machine which can process information according to a set of instructions it has been given, and store or display the results.

Computer code The patterns of pulses and no-pulses which represent the 1s and 0s of binary code with which the computer does all its work.

Dedicated computer A computer programmed at the time of manufacture to do certain tasks only.

Hardware All the physical equipment of a computer, or computer game. The chips, printed circuit board, cartridges, etc, but excluding the program.

Liquid crystal display (LCD) A kind of display often used in hand-held electronic games and calculators. It contains liquid crystal which turns black when it receives a pulse of electricity.

Microprocessor A silicon chip which contains all the parts of a computer and can do the work of a computer.

Printed circuit board A board with the metal tracks for an electrical circuit printed on it. The parts of a computer game are usually assembled on a printed circuit board and the tracks carry the current between the parts.

Program A list of instructions for a computer, written in a language the computer can understand. In English, the American spelling of program has become standard to distinguish it from a TV programme.

RAM (Random Access Memory) The computer's temporary memory where information is stored while the computer is being used. It is called random access because the computer can find any piece of information in this memory without going through all the material.

ROM (Read Only Memory) The computer's permanent memory where the program telling it how to operate is stored. In a computer game the ROM contains the program which tells the computer how to play the game.

Books about microcomputers and programming

Introduction to Computer Programming by Brian Reffin Smith, Usborne 1982
Understanding the Micro by Judy Tatchell and Bill Bennett, Usborne 1982
Illustrating Basic by Donald Alcock, Cambridge University Press 1977
Computer Spacegames by Daniel Isaaman and Jenny Tyler, Usborne 1982
Computer Battlegames by Daniel Isaaman and Jenny Tyler, Usborne 1982

Some computer stores and bookshops also sell books containing games programs for microcomputers and most newsagents sell computer magazines which also contain listings. Make sure the programs are in the correct language for the computer you use.

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Video creatures answers

1. Centipede; **2.** Warrior from Wizard of Wor; **3.** Briter from Defender; **4.** Donkey Kong; **5.** Bomber from Defender; **6.** Monster from Pac-man; **7.** Spiker from Tempest; **8.** Pac-man; **9.** Alien from Space Invaders; **10.** Submarine from Cosmic Avenger; **11.** Worluk from Wizard of Wor; **12.** Fuseball from Tempest; **13.** Mutant from Defender; **14.** Galaxian; **15.** Defender; **16.** Wizard of Wor; **17.** Battlezone.

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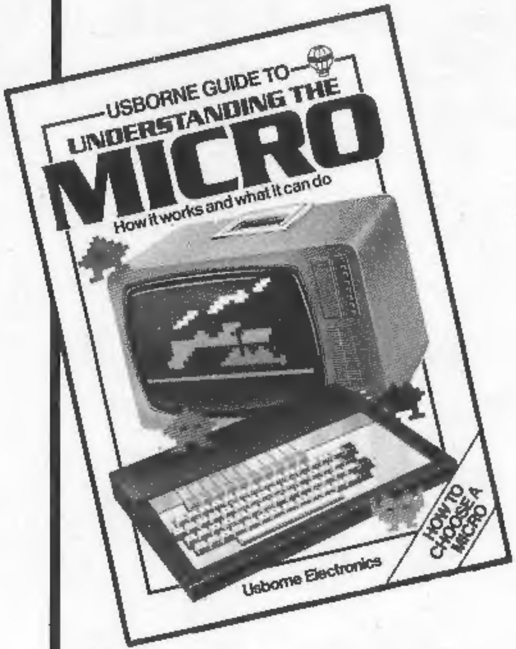

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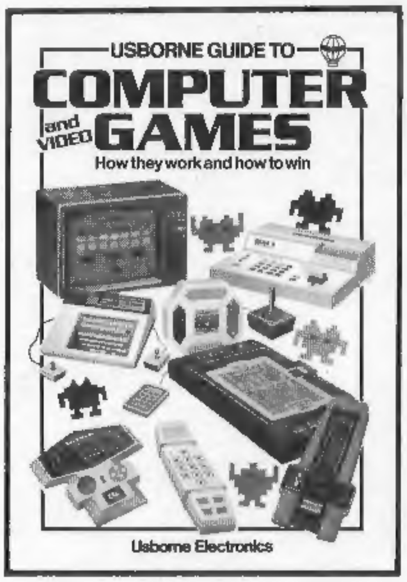

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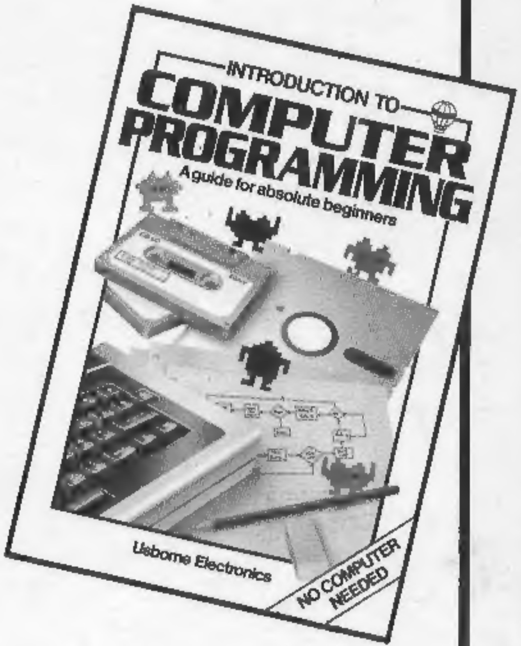

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A step-by-step guide to programming in BASIC for absolute beginners. With lots of programs to run on any microcomputer.

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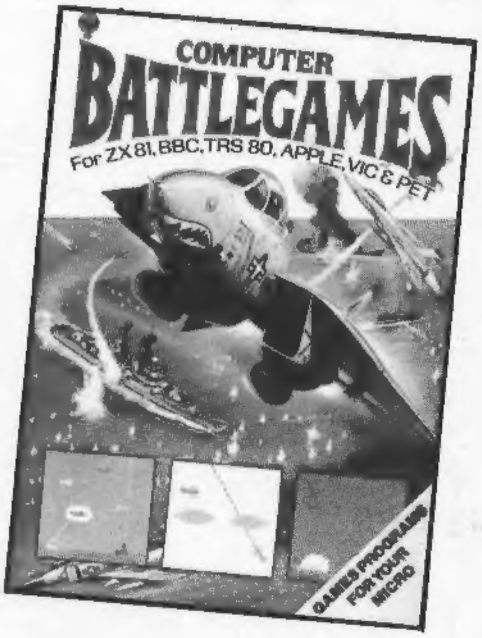
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